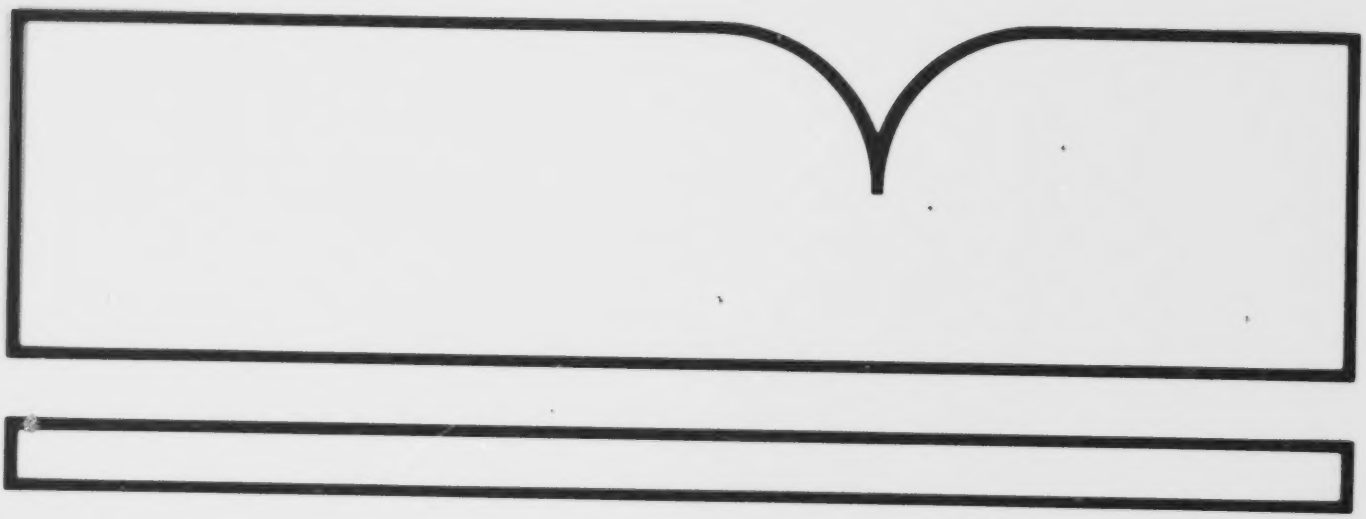
PB88-238209

Long-Range Research Agenda for the Period 1989-1993

(U.S.) Environmental Protection Agency
Washington, DC

Mar 88



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TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO. EPA/600/9-88/008	2.	3. RECIPIENT'S ACCESSION NO. PB88 238209/AS
4. TITLE AND SUBTITLE Long-Range Research Agenda for the Period 1989-1993		5. REPORT DATE March 1988 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Research and Development U. S. Environmental Protection Agency Washington, D. C. 20460		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA-600/00
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

This document is prepared in response to a Congressional requirement that the U. S. EPA submit an annual revision of a comprehensive five-year plan of research, development and demonstration. The revision contains the plans for no growth, moderate growth, and high growth budget projections in research. The research is described in media-specific terms--air/radiation, water, pesticides/toxics, hazardous waste/superfund, multimedia energy, and interdisciplinary issues.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED 20. SECURITY CLASS *(This page)* UNCLASSIFIED	21. NO. OF PAGES 92 22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

United States
Environmental Protection
Agency

EPA/600/9-88/008
March 1988

Research and Development

PB88-238209

EPA

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REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

EPA 600/9-88/008
March 1988

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Preface

The primary goal of the U.S. Environmental Protection Agency is to reduce the risks posed by pollutants to public health and welfare and to natural ecosystems. Within this context, the Office of Research and Development (ORD) provides the scientific information necessary to determine the extent of these risks and to develop and evaluate technology options to reduce, eliminate, or prevent them. As part of this process, the research program must anticipate and address both the fundamental needs of regulatory decision making and program-specific issues. Fundamental needs include reliable estimates of the risk of adverse impact to public health and the environment associated with any policy action, reliable estimates of cost-effective risk reduction options, and reliable measurement methods for the indicators used to specify the state of the environment.

These needs drive a continuing core research program consisting of:

1. Human health risk methods development and application,
2. Ecological risk methods development and application,
3. Total exposure methods development and application, and
4. Risk reduction research.

Health, ecological, and exposure issues are the foundation of risk assessment research; risk reduction research provides the regulatory decision maker with risk management tools--for setting priorities, choosing control actions, and developing environmental policy.

In the human health risk assessment area, long-term research activities will focus on methods for assessing cancer and non-cancer endpoints, improvements in techniques for using data from epidemiological, clinical, and animal studies for estimating health risks to humans, the development of statistical models that characterize dose-response relationships and associated uncertainties, and determinations of the utility and limitations of structure-activity relationships for estimating the potential toxicity of untested chemicals.

For the major category of ecological risk assessment, emphasis will be placed on research that contributes to the improved prediction of the impacts of pollutants on ecosystem function and structure, on techniques for assessing effects from complex mixtures of chemicals, and on characterizations of the uncertainties engendered by risk estimates.

In the major area of total exposure methods development, emphasis will be directed to techniques for determining frequency distributions of exposures to toxic chemicals in the population. Biological indicators of exposure and effect in human and ecological populations will be emphasized through the use of pharmacokinetic and metabolic information.

In the area of risk reduction/control technology, emphasis will be placed on developing source assessments and transport, transformation, and fate models as well as working with industry to explore alternative treatment technologies such as biodegradation (biosystems), advanced separation processes, advanced thermal degradation, and waste stabilization techniques.

These long-term research activities have evolved from a process of mediation between research concepts and regulatory/programmatic applications, as well as from a growing fund of commonly held priorities based on risk management for environmental protection. As the Agency continues to refine planning strategies for addressing increasingly complex environmental problems, it is the goal of the research program to affect those strategies with sound science, sound judgment, and vision.

Vaun A. Newill
Assistant Administrator for
Research and Development

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I. INTRODUCTION

Congressional Request

The Long-Range Research Agenda is prepared in response to the Congressional requirement that the U.S. Environmental Protection Agency (EPA) submit an annual revision of a comprehensive five-year plan for environmental research, development, and demonstration not later than two weeks after the President submits his annual budget to the Congress (P.L. 94-475, Section 5, 10/1/76; P.L. 95-155, Section 4, 11/8/77). The annual revision is required to convey the plans for no growth, moderate growth, and high growth budget projections and should include an explanation of the relationship between research activities and existing laws which authorize environmental research, development, and demonstration. The budget projections contained herein assume a 3% increase for the moderate growth scenario and a 6% increase for the high growth scenario. The budget projections are subject to change associated with new Agency priorities and the availability of funds.

Office of Research and Development (ORD) Mission and Obligations

ORD is obliged to develop and implement an integrated program which supports the mission of the Agency. Its mission is to administer, in a comprehensive and balanced manner, specific federal legislation developed to control and abate adverse impacts of pollution on the human environment (National Environmental Policy Act, 1969; Presidential Reorganization Plan #3, 1970).

In keeping with that mission, Agency management requires quality information on a timely basis for decisions relating to the assessment and management of risk from known and anticipated environmental pollution. Agency management must make decisions regarding the development of policy, guidance, standards, and regulations; monitoring programs (surveillance and compliance assessment); environmental impact analyses; quality assurance and quality control; grant applications and training.

In view of the diverse products and services required from ORD to support Agency decision making (research, problem diagnosis, technical support documents, risk assessments, expert witness consultation, quality assurance management, etc.), the ORD staff must maintain an awareness of environmental research being performed by

other governmental agencies (federal, state, and local), industry, academia, and the public interest sector. The information needs of the decision makers are critically evaluated in terms of the information available or forthcoming from all the aforementioned sources. (See Appendix for a listing of interagency coordination.)

The research in EPA/ORD focuses on those areas specified in the Congressional appropriation and on subjects considered through the planning process as not receiving sufficient emphasis to provide the information required for Agency decision making.

ORD Planning Process

Integrated planning, quality assurance programs, and peer review are all fundamental to assuring that ORD fulfills its obligations. Integrated planning of the ORD program is accomplished through the use of Agency-wide research committees, which are structured primarily along regulatory program office lines (air/radiation, water, pesticides/toxics, hazardous waste/superfund, multimedia/energy, and interdisciplinary). Membership comprises senior level representatives from the regulatory offices, the lead regions, and the ORD laboratories. Each committee is co-chaired by a senior manager from ORD and from the appropriate program office, and each office director in ORD is represented on all committees. Each committee is responsible for ascertaining the priority research and development issues of concern to the subject program office and for recommending a comprehensive, media-oriented research plan containing objectives, priorities, outputs, schedules, and resource allocations to the Assistant Administrator (AA)/ORD.

The ORD program must be flexible enough to respond to changes in Agency priorities while remaining stable enough to assure that the research undertaken results in technical information of sufficient quality to support Agency decision making. Flexibility is accommodated by reprogramming in the operating year. Priorities for reprogramming are established through discussions involving the Congress, Agency-wide management, and ORD management.

Since the ORD office directors and their respective laboratory directors are responsible for implementing the program and for obtaining peer reviews of their respective programs on a regular basis, they offer recommendations to the AA/ORD concerning the program as viewed from an integrated disciplinary perspective. Based upon these recommendations and interactions with the program office

Assistant Administrators, the AA/ORD proposes an integrated ORD program to the Administrator. The program establishes an appropriate balance between top down and bottom up planning as recommended by the National Academy of Science (Analytical Studies for the U.S. Environmental Protection Agency, Vol. III, Research and Development in the EPA, Commission on Natural Resources, National Research Council, 1977).

Plan Perspectives

Several alternative frameworks can be used to categorize the total ORD program. Examples of the suggested perspectives for categorizing the program include legislative, regulatory program office, research discipline, source, pollutant, and effects. Unfortunately, no single focus is ever fully satisfactory to the variety of groups interested in the ORD program, especially in the case of ORD special interest cross media, multidisciplinary studies. Since the Congressional request requires an indication of the relationship of plans to existing laws authorizing the Agency's environmental research, development, and demonstration work, the total program is presented primarily from the research committee perspective, which is equivalent to the regulatory office perspective. Cross media, multidisciplinary problems receiving special emphasis at present and for the foreseeable future and the research committees contributing to resolution of these problems include the following:

1. Ground water (water, hazardous waste/superfund, pesticides/toxic substances);
2. Total exposure assessment measurement (air, water, hazardous waste/superfund, pesticides/toxic substances);
3. Municipal waste combustion (air, hazardous waste/superfund);
4. Accidental releases (air, water, hazardous waste/superfund);
5. Comparative risk for complex mixtures (air, water, hazardous waste/superfund, pesticides/toxic substances);
6. Acid deposition (air, water, energy); and
7. Biotechnology (air, water, pesticides/toxic substances).

A letter commenting on the review of the ORD program by the Agency Science Advisory Board (SAB) is presented in the Appendix.

II. RESEARCH COMMITTEE (LEGISLATIVE) PERSPECTIVES

Each of the media-specific research programs contains elements which are related to the core research program. The media-specific issues and associated research planned to resolve these issues are described in the following paragraphs.

Air/Radiation

Under the Clean Air Act (CAA), EPA is responsible for setting ambient air quality standards for air pollutants emitted from both stationary and mobile sources. National Ambient Air Quality Standards (NAAQS) have been set for six criteria pollutants: ozone (O_3), carbon monoxide (CO), particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb). These standards must be reviewed every five years and revised if appropriate. Compliance with these standards is the responsibility of each state through the development and implementation of State Implementation Plans (SIPs), which limit emissions from sources, set time tables for compliance, and establish monitoring procedures. The Agency is also responsible for setting technology-based New Source Performance Standards (NSPS) to limit air pollutant emissions from new sources or from existing sources that have been modified. In areas where the air quality is better than that required to meet primary and secondary standards, emissions from new or modified sources are restricted under the Prevention of Significant Deterioration (PSD) program. EPA is also responsible for limiting emissions of air pollutants that are hazardous to human health but are not already regulated as criteria pollutants. Included are volatile organic carbons (VOCs), which are ozone precursors. In addition, Title IV of the Superfund Amendments and Reauthorization Act of 1986 (SARA) authorizes research and other technical activities on indoor air and radon.

ORD provides the scientific data bases, methods, models, assessments, emission reduction technologies and corresponding quality assurance support to implement these legislative authorities. Within the scope of the air research program, seven major issues have been identified which cut across scientific disciplines and the pollutant-specific structure of the research program. In addition, EPA conducts a radiation monitoring and quality assurance program.

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EPA has identified several topics in the air research program that will require special attention in the coming years. Among these are support for the ozone attainment program, stratospheric ozone, and global climate modification. In addition, attention is being turned to the problems of unregulated pollutants in urban air and the effects of ozone on forests. These issues will be emphasized during the next five years of air pollution research.

Major Research Issues

Criteria Pollutants

What scientific support is necessary to develop and review primary and secondary NAAQS?

Health Effects: For each of the criteria air pollutants, many of the sensitive population groups and the pollutant exposure ranges of interest have generally been identified. However, health effects testing of these pollutants must continue in both animal and human subjects to ascertain dose-response relationships. The health endpoints of concern are mainly respiratory, metabolic, and immune system effects of O_3, NO_2, SO_2 and particulate matter, and the cardiovascular and neurologic effects of CO. In addition, research may be done on the health effects of very short exposure to high levels of particles and SO_2. This research would support reevaluation of emergency level standards, particularly as they apply to sources that emit occasional bursts of pollutants for extremely short periods of time. Emphasis will also be placed on evaluating the effects of long-term, low-level versus short-term, higher-peak exposures to oxidants, particularly NO_2, and the effects of both long-term and short-term exposures to the coarse fraction of airborne particles smaller than 10 microns in diameter. The information obtained from this research will be factored into the next round of criteria documents and used in the review of NAAQS.

To improve our ability to relate animal data to actual human consequences and to develop more reliable risk estimates of exposure to air pollutants, techniques will be developed to extrapolate from animal to human effects, from high to low doses, and from acute to chronic effects. To do this, information in three critical areas will be considered: dosimetry--the amount of pollutant which reaches specific target sites in the body after exposure to a given concentration of pollutant; species sensitivity--

the potential variations in response of different animal species to the same dose of pollutant; and dose/response.

Human volunteers are being exposed to criteria pollutants for brief periods of time at concentrations similar to those encountered in daily life, in order to measure the resulting effects on heart and lung function, immune response, and other physiological and biological parameters. Similar studies are being conducted with animals. Animals are also being exposed chronically to these pollutants, and the cumulative lifetime effect of these exposures will be determined. These dose-response data, combined with dosimetry and species-sensitivity information, provide the information necessary to infer the effects that chronic exposure to a given pollutant may have on humans.

Epidemiological research provides the most direct evidence of human health effects from environmental exposures to pollutants. Epidemiological studies are being done to ascertain the health effects of total exposures (indoor and outdoor) to the criteria air pollutants.

Welfare Effects: To assess the need for secondary air quality standards for criteria pollutants, research is needed on the impact of air pollution on vegetation and visibility degradation. Recent research on the effect of O_3 on crops indicates that fluctuations of O_3 levels in conjunction with other conditions may seriously affect crop plant response. Field work under way to quantify and reduce these uncertainties and to provide information for use in economic models will continue at several sites. Ozone exposure research on forages and some work on models will continue.

Whereas crop model research will be reduced, increased effort will be invested in a research program to determine the damage done to forests by ozone. For regulatory purposes EPA needs to quantify O_3 effects on forests to determine what types of forests are affected and to establish their relative sensitivity; to define dose-response relationships that allow estimates of benefits from reduced O_3 exposure; and to translate the data into air quality standards. The experimental approach will closely follow that taken with crops, but perennial trees will be utilized rather than annual plants.

Atmospheric Processes: Research will be conducted to determine the extent of visibility impairment. Specifically, the role of aerosols on visibility reduction will be assessed; visibility trends for the U.S. will be determined using available data bases; and measurement and monitoring

techniques will be developed to characterize more completely the extent of visibility changes. A regional visibility research network will be established to provide data for analyzing source-receptor relationships, and models will be developed to assess visibility protection strategies. Research is also needed to assess the influence of particle size and composition on soiling and to aid in the development of a risk assessment.

Monitoring: New and improved monitoring methods are needed to identify areas where public health and welfare are threatened and to establish air quality trends. In addition, accurate, reliable monitoring methods are necessary to determine compliance with standards and to evaluate the need for enforcement actions. This will be carried out through the testing, evaluation, improvement, and standardization of methodologies and systems for measuring ambient pollutants. Emphasis will be on non-methane organic compounds and fine particles.

Quality assurance is required to provide a reliable estimate of the precision and accuracy of the data obtained from measurements from sources such as the State and Local Air Monitoring Networks. This is carried out through the use of audits of the laboratories and from the use of standard reference materials that have been prepared, verified, and distributed to the user laboratories.

Scientific Assessment: The review and revision of NAAQS is a continuing effort, based upon new and evolving scientific information. ORD contributes to this function by publishing new or revised Air Quality Criteria Documents (AQCDs) that are then used by regulators to revise NAAQS. In the immediate future, revision of the criteria documents for CO and NO_x will continue, and an addendum to the PM/SO_x criteria document will be completed. Technical evaluations are being conducted for use by the regulatory office in evaluating the NAAQS for lead, SO_x, O_3, and PM and for determining whether to list acid aerosols as a criteria pollutant.

New Source Performance Standards (NSPS) and State Implementation Plans (SIPs)

What scientific support is needed to develop NSPS and SIPs?

Control Technology: Research will be conducted to characterize emission sources and evaluate and improve the cost-effectiveness of emission reduction technologies, thereby reducing the cost of complying with SIPs.

Improved control technology is also needed for sulfur and nitrogen oxides. For SO_x, further research will be conducted on conventional spray drying for utility and industrial boilers. Also, comparative assessments are needed for various absorbents to reduce the cost of spray drying flue gas desulfurization (FGD). The role of dry injection techniques in FGD systems will also be investigated. Research to control NO_x will focus on evaluating the applicability of combustion modification techniques to industries. Needed research on reburning and changes in precombuster burner designs will continue.

Research to control particles focuses on improving the performance, reliability, and cost-effectiveness of the multi-stage electrostatic precipitators (ESPs) and fabric filtration. The major purpose of this research is to improve collection of small particles that have become increasingly important in meeting particle standards. ESPs may assist in acid rain mitigation when used with dry add-on SO_2 removal processes. Precipitators are also appropriate when facilities switch to low-sulfur coals, with their more difficult-to-collect fly ashes. Another particle control measure that shows promise is electrostatically augmented fabric filtration (EAFF). Also, recent research indicates that proper conditioning of the particulate matter can reduce pressure drop significantly, resulting in fabric filters one-third the size of conventional units. Additional research to verify this finding is necessary and has begun.

Atmospheric Processes: Pollutants emitted into the air often undergo chemical reactions that change them into different compounds. Models to predict this phenomenon are being developed at the urban and regional scale. These models will provide information necessary to develop, evaluate, and implement cost-effective air pollution control strategies for SIPs and PSD determinations.

Over the last few years, a variety of air quality models have been developed; however, evaluations of these models indicate that the accuracy and reliability of their predictions need to be increased. In order to improve urban scale models, smog-chamber studies will be conducted to obtain a better understanding of the atmospheric chemical processes associated with the formation of oxidants and inhalable particulate matter. Emphasis will be placed on the impact of lower hydrocarbon/NO_x ratios and the role of specific categories of VOCs such as aromatic hydrocarbons and aldehydes in producing atmospheric ozone and other oxidants. Source

apportionment modeling techniques will be developed and evaluated for both non-volatile and volatile organics.

In order to make dispersion and mathematical models available to the regulatory and research community, the User Network for Applied Modeling of Air Pollution (UNAMAP) will be updated to include state-of-the-art models.

On the regional scale (up to 1,000 km), laboratory and field studies will be conducted to improve the ability of models to predict the atmospheric transport, transformation, and deposition processes for air pollutants such as ozone and particulate matter. Alternative mathematical techniques and new meteorological tracers will also be evaluated to determine their ability to improve modeling predictions. The regional scale models will be adopted to predict both episodic (hours, days) and longer (months, seasons) time periods.

Monitoring: Research will be conducted to improve standardized methods for monitoring stationary sources. In order to increase the precision and accuracy of these monitoring systems, audits and quality assurance assistance will be carried out for state, local, or federal laboratories involved in measuring NO_x, organic precursors, SO_2, sulfate, particulates, or lead. Necessary reference materials and guideline documents will be provided to implement the requirements of the CAA. Quality control standards will also be prepared, verified, and distributed to these laboratories.

Remote monitoring systems are being developed, evaluated, and applied for use in areas where data are needed for SIP evaluation or revision and for Agency evaluation of the need for new standards.

Hazardous Air Pollutants (HAPs)

What scientific support is needed for regulatory decisions about potentially hazardous air pollutants?

Monitoring: Few monitoring methods are available for measuring concentrations of and human exposure to potentially hazardous air pollutants, especially organic compounds; therefore, new sampling and analytical systems and a set of validated source-sampling methods will be developed for important sources of hazardous air pollutants that currently cannot be monitored with adequate precision and accuracy. Research to develop methods of monitoring ambient hazardous air pollutant concentrations will be accelerated, as will work on passive monitors and new sorbents. This will extend the

measurement capability to chemicals not collected by current methods and to new monitoring situations such as exposures near hazardous waste sites. The nationwide Toxic Air Monitoring System (TAMS) will be continued, to characterize urban atmospheres and determine the magnitude and extent of the hazardous air pollution problem. In addition, TAMS will support the "urban soup" program, which is a multidisciplinary effort to characterize and assess risks from a complex mixture of pollutants in urban areas. The previous Total Exposure Assessment Methodology (TEAM) studies will be evaluated and several focused TEAM exposure studies will be undertaken to better document and define the human exposures to HAPs and the sources of these exposures. The TEAM methodology will be extended to other pollutants and other areas of the country to determine the relationship of exposures to geographical factors.

Health Effects: In general, the strategy for investigating the health effects of toxic air pollutants must be quite different from that employed in the study of criteria pollutants. First, because of the potential hazards of these pollutants, clinical studies of exposed human volunteers cannot be conducted; however, epidemiological studies may be feasible. Because direct animal-to-man extrapolation is difficult, it is necessary to develop animal models that use biological indicators of neurotoxic, genetic, reproductive, or developmental effects in order to predict effects in humans. Research to develop such models will be undertaken during the next five years. Inhalation exposure chambers are being used to study pulmonary, developmental, neurotoxic, and other effects of priority air pollutants on animals.

Control Technology: The highest priority for research in this area is to assess technologies for their ability to reduce toxic emissions from various industrial and combustion sources. These include both gaseous and particulate species. A near-term goal is to control emissions from wood-burning stoves, beginning with evaluations of the efficiency and longevity of wood stove catalysts.

As part of the long-term strategy to control HAPs, industries that are deemed to be high-priority sources of HAPs will be identified. Such industries include petroleum refineries, organic chemical manufacturers, and iron and steel mills. Research will be performed to develop efficient and effective control strategies for such high-priority emitters.

Because much is already known about other criteria pollutants, priorities for research in control technology have shifted to volatile organic compounds (VOCs), to assist in meeting ozone level attainment goals. VOCs, which react with NO_x and sunlight to produce ozone, are a major cause of the ozone non-attainment problem. Although emissions from major stationary sources are being reduced, small sources, such as dry cleaners, gas stations and paint users, are not being widely controlled. Although these sources individually emit small amounts of pollutants, collectively they may constitute a significant problem. Control technologies such as industrial flares, carbon adsorption, catalytic oxidation, thermal incineration, and other advanced technologies, as applicable, will be assessed to determine their performance and cost in reducing VOC emissions from such sources. Emphasis will be placed on developing and evaluating methods to control VOCs without resorting to costly add-on control devices.

Atmospheric Processes: Consideration of the formation, atmospheric stability, and removal of HAPs is essential in assessing exposure and risk. Of particular concern is the formation in the atmosphere of toxic pollutants from chemical reactions among individually innocuous compounds. On a schedule consistent with the Agency's regulatory calendar, laboratory and field studies will be performed to determine the reaction rates, products, and natural variabilities of HAPs under review. Chemistry will be studied in isolated laboratory systems to obtain accurate data on kinetics and mechanics. HAPs will also be investigated in photochemical smog chambers, which provide a better basis for extrapolation to the atmosphere. New studies will be undertaken to determine the extent to which HAPs are formed in the atmosphere from innocuous compounds.

Integrated Air Cancer Program: There is a great deal of uncertainty regarding the relationship between air pollution and human cancer. Determining the extent to which air pollution is responsible for or related to human cancers could have a major impact on EPA's regulatory program. Thus, a long-term, interdisciplinary research program has been developed to address the major scientific questions regarding the relationship between air pollution and the development of human cancer.

The three basic goals of this program are to identify the principal airborne carcinogens; to determine which emission sources are major contributors of carcinogens to ambient air and which chemicals are carcinogen

precursors; and to improve the estimate of exposure and comparative human cancer risk from specific air pollutant emission sources. Field tests of relatively isolated single-source categories are essential for developing methods to evaluate the more typical multiple-source environments to which the general population is exposed. A current study focuses on quantifying carcinogens emitted from residential wood-fired combustion systems and motor vehicles. The results of this study will be immediately useful, particularly as surrogates for similar environments, while the study design can be adapted for use in more complex environments.

In the monitoring and modeling component of the project, samples of ambient air in the "breathing zone" of persons in an urban/industrial area and a suburban area are being collected and analyzed for carcinogens and mutagens. Comparisons between the ambient and personal samples and between the urban and suburban concentrations will be made, and relationships between exposure and dose will be studied. The relative importance and contribution of gaseous and volatile organic compounds and of semivolatile and particulate organic compounds to total airborne carcinogens will be determined. In addition, laboratory studies will be conducted to determine the atmospheric formation and fate of bioactive compounds.

Health research focuses on methods development and data gathering to evaluate the human cancer risk from individual and, ultimately, complex source emissions. A comparative methodology to predict risk will be adapted to evaluate and utilize short-term mutagenesis and animal carcinogenesis data on emissions. Research to identify the major sources of hazardous air pollutants and to characterize these emissions from various combustion sources of primary concern will serve as the basis of the engineering component of the project.

Scientific Assessment: A three-tiered process is employed in assessing scientific data bases for substances considered to be HAP listing/regulation candidates. Tier I reports are an initial review of literature on health effects associated with a given chemical or class of chemical substances. If no adverse health effects are found likely to be associated with exposures and the Office of Air and Radiation (OAR) decides not to list the substance as a HAP, then the Tier I report is published. However, if significant effects appear likely, then a draft Health Assessment Document (HAD) is prepared for review by a scientific workshop (Tier II). The final tier (Tier III) would include public review and comment, SAB review,

and publication of the HAD. In the coming year, final comprehensive HADs will be completed on four chemicals and External Review Drafts (ERDs) will be prepared for three to six chemicals. Tier I screening documents for four to six chemicals will be completed and another three to six will be initiated. Increased emphasis will be placed on toxic mobile source pollutants and non-cancer endpoints. Technical assistance will be provided to the regions and states on issues related to air toxics. Risk assessment methods will be developed on specific non-cancer health effects. As part of this new effort, techniques for using pharmacokinetic information in risk assessments will be developed. Future emphasis will be placed on toxic effects rather than on cancer issues, since the majority of the cancer-causing high priority pollutants (list of 25) have been scientifically evaluated and now are entering their regulatory pathways.

Mobile Sources

What scientific support is needed to develop mobile source regulations?

Atmospheric Research: As the driving fleet ages and changes occur in engine design, models to assess the impacts of mobile source emissions on ambient air quality need to be refined, and studies must be conducted to evaluate the impact of new emissions. Greater emphasis will be placed on evaluating promising alternative fuels, particularly methanol. The two primary pollutants of importance from methanol-fueled vehicles are methanol and formaldehyde. Analytical procedures to measure methanol and formaldehyde will be developed and emission characterizations performed. Research to determine the photochemistry of emissions from methanol-fueled vehicles will also be conducted. Emissions from future gasoline-fueled vehicles and diesel-fueled vehicles equipped with advanced control technologies will be characterized. Also, evaporative emissions from motor vehicles will be characterized under a number of simulated driving conditions.

Monitoring: Improved exposure-activity pattern models will be developed from exposure data from past field studies. Further refinements of the Simulation of Human Activities and Pollutant Exposures (SHAPE) model will be conducted, and the basic modeling approach will be adapted to additional mobile source air pollutants. Validation of the SHAPE model and other exposure models will continue using existing human exposure data

bases. Such tools are required for making adequate estimates of risks from mobile source air pollutants.

Health Effects: Studies of the cardiovascular and neurotoxic effects of CO will continue. A new research effort on the health effects of fuel and fuel additives will begin. The Health Effects Institute is expected to continue its program on CO, NO_2, O_3 and diesel exhaust, and aldehyde research, and new emphasis will be placed on studies to support risk assessment for diesel exhaust.

Global and Microenvironmental

What scientific data are needed to determine the impact of the quality of global and micro-environments on public health and the environment?

Stratospheric Modification: By preventing most harmful ultraviolet (UV-B) radiation from reaching the earth's surface, the stratospheric ozone layer serves as an important shield protecting human health and welfare. It is being accepted that chlorofluorocarbons (CFCs) cause depletion of stratospheric ozone if present in sufficient quantities. Several serious consequences are possible, including (1) increases in melanoma and other skin cancers, (2) suppression of the human immune system, (3) decreased productivity of commercial crops and aquatic organisms, and (4) accelerated degradation of polymeric materials.

In addition, there has been much interest in the link between CFCs and possible climate change effects brought about by the increase in carbon dioxide and other trace gases and the "Greenhouse" effect. Substantial evidence exists that the composition of the global atmosphere is changing, particularly with respect to carbon dioxide and trace "Greenhouse" gases that affect the energy balance of radiation to and from the earth's surface and atmosphere. The precise timing, magnitude, and spatial patterns of the atmospheric effects are uncertain, but there are indications that changes may occur leading to long-term increases in surface temperatures and to shifts in sea-level elevations and in global, climate, and hydrology patterns. The research program under development provides for a coordinated effort focusing on ecological effects research, development of control technology, and determinations of the factors influencing the formation, transport, and fate of pollutants affecting global weather.

The signing of the "Montreal Protocol on Substances that Deplete the Ozone Layer" on September 16, 1987, set deadlines for decisions on tightening existing controls on ozone depletion by 1994. ORD is developing a research plan for meeting the needs of Agency policy makers under the Montreal Protocol. To help accomplish this, the Stratospheric Ozone Research Program will be significantly enhanced in Fiscal Year 1989.

Research will be conducted to determine the emissions that destroy stratospheric ozone and the technologies that control these emissions.

With regard to UV-B light, research is planned to (1) evaluate potential future rates of growth in CFC emissions; (2) model changes in the ozone layer that may result from changes in atmospheric composition; (3) analyze predictive models in light of new atmospheric monitoring data; (4) determine potential health effects, particularly the contribution of increased UV-B radiation to the development of malignant melanoma; and (5) determine the effects of UV-B on marine ecosystems.

In conjunction with other agencies, research will be accelerated on the development, validation, and use of global tropospheric/stratospheric chemistry models to predict the impacts of changes in trace gases, temperature, and humidity on global climate and the resulting effects on health and welfare. Results will be incorporated into an international strategy for dealing with trace gases that affect climate. Effects of global warming on crops, marine and terrestrial systems, and other biota will be estimated.

Indoor Air: In the 1970's, indoor air pollution began to attract increasing public attention when the federal government encouraged energy conservation measures for buildings.

As Congressional interest in indoor air quality began to surface, EPA and other federal agencies were directed to begin exploring the dimensions of the potential indoor air quality problem. As a result, in 1982 and 1983, approximately $500 thousand were appropriated to EPA each year for research on indoor air. For fiscal years 1984, 1985 and 1986, resources totalling approximately $7 million were appropriated for research on indoor air and radon gas mitigation technologies. EPA has coordinated its research on indoor air quality with its federal agency partners on the Committee on Indoor Air Quality, formed in 1983.

In September 1986, EPA's SAB reviewed ongoing research projects in indoor air quality and endorsed the Office of Research and Development's plan to conduct a Research Needs Assessment to determine what is currently known about indoor air problems and what critical research needs to be done. In October 1986, Title IV of SARA mandated that EPA conduct an indoor air research program. Subsequently, ORD formulated a research framework around which the research program is structured. The program was designed to meet research needs that have been divided into three categories: source-specific (e.g., environmental tobacco smoke, combustion appliances); building and ventilation; and generic issues (e.g., monitoring, demonstration projects). In June, ORD and the Office of Air and Radiation submitted the EPA Indoor Air Quality Implementation Plan to the Congress. This document included ORD's Preliminary Indoor Air Pollution Information Assessment, a description of the FY 87 Indoor Air Research Program, and an Indoor Air Reference Data Base. The two offices are continuing to develop the process of coordinating the Agency's indoor air policy. At the same time, in accordance with SARA, ORD is coordinating the indoor air research activities of other federal agencies through the interagency Committee on Indoor Air Quality (CIAQ). This effort will produce a Research Needs Statement, which, when finalized by the CIAQ, will be incorporated in the 1988 Indoor Air Report to Congress being coordinated by OAR.

NHANES-III: EPA is participating in an interagency consortium that will conduct the next National Health and Nutrition Examination Survey (NHANES-III). EPA's chief goal in this endeavor is to obtain national baseline data on a variety of factors that affect pollutant exposures and that influence health outcomes associated with those exposures.

Radiation Research

What technical support is necessary to ensure that the public is adequately protected from exposure to radioactive materials in the environment?

Monitoring: On a continuing basis, EPA supplies comprehensive radiological monitoring and surveillance services to the Department of Energy (DOE) to meet that Agency's nuclear test monitoring requirements, especially at the Nevada Test Site. Other locations at which such support is regularly provided include Mississippi, Colorado, and New Mexico. Advanced monitoring systems are employed, primarily offsite, to measure the amount of radiation escaping the site following test blasts. A report

is generated yearly which details the locations monitored and test results. This work is expected to continue at the same level of effort during the next five years.

EPA conducts a radiochemical analytical quality assurance program that supports federal, regional, state, and local laboratories that measure radioactivity to assess the impact of local nuclear facilities. The purpose of this program is to ensure that scientifically credible data, methodologies, and assessments are used when determining public exposure to radioactive materials. Each year, EPA reports on laboratory radionuclide studies conducted during the previous year. This is a continuing effort and is expected to remain at its current level.

Radon: In support of EPA's Radon Action Plan, ORD will continue developing and demonstrating cost-effective methods of mitigating and preventing the entry of radon from soils and ground water into homes and other structures. Publications directed to states, builders, homeowners, and businesses on protecting against elevated indoor radon levels will be produced and updated, based on the results obtained from additional field demonstrations and other newly available information. Our radon activities will be coordinated with DOE's enhanced radon research program.

Summary of Long-Term Trends

During the past 15 years, much progress has been made in cleaning up the nation's air. Increased use of lead-free gasoline has sharply decreased ambient lead levels, and the recent move to speed up the lead phase-down program promises to cut these levels even further. Urban areas are experiencing fewer severe pollution episodes. Catalytic converter use has greatly diminished carbon monoxide and hydrocarbon emissions from automobiles. Although some areas still exceed allowable levels of ozone, most locations across the country are generally in compliance with NAAQS.

Given these trends, priorities are shifting in the air research program. New questions include: What are the hazards posed by unregulated toxic pollutants? What are the sources of these pollutants? Do the complex mixtures of urban air pollutants pose particular dangers? What are the long-term health consequences of continued exposure to low levels of criteria pollutants? What physical and chemical interactions in the atmosphere can create or increase toxic pollutants? What are the actual pollutant exposures encountered by people throughout the day? To what extent do conditions or materials in the

home contribute to those exposures? What effects do man-made pollutants have on global climate? Does ozone have a negative effect on commercial species of trees? What can be done to minimize health threats from accidental releases of toxic air pollutants? What technology is available to control emissions from incineration of municipal wastes? What health effects are associated with these pollutants?

Within the area of toxic air pollution research, EPA will focus on several objectives. Monitoring methods will be improved, and attempts will be made to characterize urban atmospheres and determine national pollution trends. TEAM studies will be undertaken, with the goal of developing a profile of HAP exposures across the nation. Efforts will be made to identify the most toxic pollutants, by source, and to determine their health effects. The formation, transport, and fate of HAPs will also be investigated. The Integrated Air Cancer Program (IACP) will be continued, drawing on the resources of several EPA laboratories to discover the extent to which toxic pollutants contribute to this country's rising cancer rates. The health effects of pollutants associated with the burning of municipal wastes and with new motor vehicle fuels will be studied. Research on control technology for municipal waste incineration will be performed.

With the cooperation of other federal agencies interested in the hazards of indoor air pollution, EPA will be applying modern methods to monitor indoor exposures to radon, VOCs, NO_2, particulate matter, and other contaminants. Indoor emissions will be characterized and exposure models will be constructed to predict indoor exposures to specified pollutants. Ultimately this information will be of use in determining the total exposure--indoor and outdoor--that humans receive to these pollutants.

Within the criteria pollutant program, an important new issue is the need to determine the extent to which ozone is responsible for damage to forests, low growth rates, and susceptibility to disease. Additional remaining concerns include ozone non-attainment and health effects of exposures to NO_2 and particulate matter. Ozone control research will focus on small stationary sources of VOCs, such as dry cleaners and gas stations, to develop applicable, low-cost methods of cutting VOC emissions. Health research on NO_2 will concentrate on clinical, epidemiological, and toxicological evaluations of exposure, particularly in susceptible populations, such as children and persons with impaired respiratory systems.

The recent Montreal Protocol focused international attention on the problem of stratospheric ozone depletion. In order to meet the Protocol's 1994 deadline, ORD is initiating a major research effort on the effects of ozone depletion and the resulting increases in UV-B radiation on human health and the environment.

Resource Options

1988 Revised Current Estimate: $ 68.7M
1989 President's Budget: $ 76.5M

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	76.5	76.5	76.5	76.5
Moderate	78.8	81.2	83.6	86.1
High	81.2	83.6	86.1	88.6

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional efforts would be devoted to augmented research in risk assessment, formation and control of ozone, long-term health effects of pollutants, and mitigation of risk. Specifically, emphasis would be placed on determination of risk. Reduction in the criteria air pollution program would be restored.

High: Additional emphasis would be placed on determining subtle but major health risks from both criteria and non-criteria pollutants. Additional support would be given to control technology research and efforts to characterize dispersion patterns and atmospheric reactions of pollutants. Research outreach activities would increase, including technical assistance, technology transfer, and regulatory support.

Water

EPA's water research program provides the technical and scientific support necessary to implement the Agency's regulatory responsibilities under the Clean Water Act (CWA), the Safe Drinking Water Act, the Marine Protection, Research and Sanctuaries Act, and a number of Executive Orders and omnibus statutes. About half of the research on water issues is conducted by the ORD laboratories, and a valuable contribution is also made by universities and private research institutions supported in part by EPA grants and cooperative agreements. EPA's water research is important to the development of both drinking water and water quality regulations. The program is heavily involved in the evaluation of innovative and cost-effective treatment technologies and the provision of technical assistance to municipalities, industry, and private landowners. In addition, research is accelerating on the environmental impacts of pollution upon aquatic biota and their ecosystems. Especially important is the research support of the Agency's Ground Water Protection Strategy.

The water research program will continue to provide support in the following areas: developing new and revised drinking water Maximum Contaminant Levels and Health Advisories; developing Criteria Documents and the scientific underpinnings of ambient water quality regulatory policies; assisting the regions and states in meeting the growing demand for toxicity-based NPDES permits; providing standardized monitoring methodology, quality assurance guidance, calibration reference materials, and performance audits to assess and maintain an acceptable level of self-compliance monitoring data quality; providing technical support to the municipal wastewater construction program in pretreatment, sludge, operation inflow, technology evaluation, and other areas; improving analytical and prediction technology for assessing ground-water contamination; developing cost-effective methods for cleaning up contaminated ground water; providing support for states in developing wellhead protection programs; and supporting the underground injection control regulatory program.

The six research areas described in this report--Water Quality Based Approach; Marine, Estuarine, and Great Lakes; Wastewater Treatment Technology; Drinking Water Technology; Drinking Water Health; and Ground Water--represent the principal concerns in the water research area and correspond both to the organizational

structure of the Water Research Committee and the Agency's water research budget.

Major Research Issues

Water Quality Based Approach Permitting

What information and methods are needed to support a water quality based approach to pollution control?

The CWA recognizes two types of regulatory requirements needed to restore and maintain the quality of the nation's waters: (1) technology-based guidelines to set uniform national requirements for discharges by industries and sewage treatment facilities; and (2) water quality based standards to define the uses to be made of water, such as drinking water supply or recreation, and subsequently establish site-specific criteria protective of that use. Despite significant reductions in point-source pollutant levels as a result of the implementation of technology-based discharge limits, some water bodies still do not meet water quality standards. Moreover, increasingly important water quality problems are caused by toxic substances, diffuse (non-point) sources, and reduced flow.

Ecological Hazard Assessment for Water Quality: This research will develop and evaluate regional approaches for establishing water quality standards and conducting water quality assessments. The regional integrative assessment approach, which includes the development and evaluation of ecoregion maps, an index of biological integrity for streams, and experimental designs for estimating the status of aquatic resources based on population, will be developed and refined. Water quality criteria will be evaluated to determine which chemicals pose the greatest threat to wildlife through the aquatic food chain. Ecological criteria will be developed by integrating terrestrial and aquatic characteristics into an assessment protocol.

Waste Load Allocation: Environmental processes characterizations will increase available data bases, and waste load allocation models will be developed, improved, simplified, and tested to implement the water quality based approach. The Center for Water Quality Modeling in Athens, Georgia, will catalogue, maintain and provide models, user manuals and associated training and technical assistance to EPA regions and states.

Monitoring and Quality Assurance: EPA will continue to identify, evaluate, standardize, and validate analytical procedures for characterization/monitoring of waterborne pollutants. Emphasis will be given to establishing protocols that screen water quality through biochemical and/or biological testing. In the area of chemical methods development, generic instrumentation approaches to monitoring (rather than a chemical-by-chemical approach) will be evaluated. Contamination of the water column, underlying sediment, or introduced sludge will be individually addressed in an attempt to maximize the economy of each class of measurement. Performance of analysts, laboratories, and measurement methods will continue to be assessed, and corrective action will be taken to help maintain the quality of the Agency's data base supporting critical decision making. Additionally, the proposed externalization of quality assurance costs (charging user fees for quality assurance services) will require the private sector to reimburse EPA for services rendered.

Water Quality Criteria - Aquatic Life: Toxicity testing methods for aquatic life will be developed, validated, and provided to regions and states for predicting in-stream water and biological impacts in fresh and brackish water and marine systems. Research will continue to support the integration of pollutant-specific controls with whole-effluent-toxicity testing procedures and Best Available Technology. The significance of toxicity and persistence factors to biota will be determined and methods developed for integration into the permitting process. Field tests will compare site-specific criteria modification techniques with the whole-effluent-toxicity approach. Freshwater and marine water quality criteria and advisories for protection of aquatic life based on specific chemicals will be developed as needed.

Water Quality Criteria - Health Effects: Health effects bioassays developed in previous years to determine toxicity of municipal and industrial waste discharges will be field tested at several different locations. The results of these field evaluations will be combined and produced as a methods manual to support the NPDES program.

Water Quality Criteria - Scientific Assessment: The scientific assessment program will provide guidance documents for assessing the risk of human exposure to mixtures of toxic chemicals and will evaluate site-specific health hazards, as required, by states and EPA.

Wetlands in Water Quality Protection: The wetlands research effort will establish a scientifically valid framework for assessing the cumulative impact of changes so that wetland programs can more effectively protect important environmental functions. This research will also assess the effectiveness of wetlands mitigation and determine the role of wetlands in water quality protection.

In other areas, guidance for assessing the risk of human exposure to mixtures of toxic chemicals, the evaluation of site-specific health hazards and evaluations for CWA Section 301(g) permit modification requests will continue under the scientific assessment program. The cooperative ecological research with the People's Republic of China will address the impact of contaminants on freshwater organisms, emphasizing field verification of methodologies.

Marine, Estuarine, and Great Lakes

What information and methods are needed to support environmentally sound ocean disposal, estuarine, and Great Lakes programs?

Ocean Disposal: EPA is charged with regulating waste disposal activities in the marine environment. Among these activities are the dumping of wastes such as dredged material, sewage sludge, and industrial wastes; the disposal of municipal and industrial wastewater through ocean outfalls; the incineration at sea of industrial wastes; and the permitting of discharges through the NPDES program. An improved understanding of the ecological consequences of these ocean disposal actions is needed to guide future public policy, satisfy international marine treaties, and, where possible, protect and enhance coastal fisheries resources. Key questions concerning ocean disposal actions involve procedures to be used in assessing the impacts of ocean disposal and procedures necessary to monitor dumpsites for long-term impacts and validate predictions made about potential impacts. The CWA requires secondary treatment for ocean outfall discharges from publicly owned sewage treatment plants, although waivers are allowed in selected cases. Therefore, EPA must have a scientific basis for determining when secondary treatment requirements may be modified and what effluent limitations should be imposed.

To support the ocean dumping and outfall regulatory programs, EPA's research will focus on the development and validation of protocols needed for prediction of impacts from these activities. This program will continue the development and testing of ocean disposal impact

assessment procedures, coastal and deep-water monitoring methods, and procedures for characterizing the bioaccumulation potential and effects of ocean-disposed contaminants.

Coastal Waters: Estuaries and near coastal waters are valuable ecological systems that are directly important to man as fisheries and recreation resources and indirectly important as nursery areas for estuarine and coastal fisheries. These areas are subject to impacts from the production, transport, consumption, and release of toxic chemicals. In assessing the impacts from these chemicals, basic scientific uncertainties exist which involve the quantification of loads, their transport and fate, and their cumulative effects on resources. EPA's estuarine and near coastal waters research programs will concentrate on the development and validation of hazard-assessment protocols for improved source-control decisions in the NPDES and Construction Grants Programs. The estuarine research program will develop generic procedures for conducting wasteload allocations in estuaries. The coastal waters research program will focus on the development of biomarkers, eutrophication, and ecosystem resiliency/recovery.

Great Lakes: Increased use of industrial chemicals and their presence in the Great Lakes have raised public concerns about toxic pollutants, particularly persistent synthetic organic compounds. Because many of these compounds are complex, it is difficult to predict their impact on organisms in the food chain, including humans. Analytical methods for detecting environmental concentrations of organic compounds at trace levels are often inadequate. Also, existing methods are limited in their ability to relate pollutant exposure levels to sources and to determine biological availability and environmental effects of toxic organics. EPA will continue to study transport, fate, and effects of toxic materials in selected areas of the Great Lakes ecosystem, with emphasis on contaminated sediments. This information will be used by the Great Lakes National Program Office, EPA regions, states, and the International Joint Commission under the U.S./Canada Water Quality Agreement.

Wastewater Treatment Technology

What information is needed to develop and assist the states in implementing sludge disposal regulations and to improve the reliability and cost-effectiveness of wastewater treatment facilities?

Sludge Management: The processing and disposal of sludge accounts for about half the total operating costs of a typical sewage treatment plant. Municipalities are facing increased economic and public problems with current land and ocean sludge disposal practices. Approaches to disposal are needed that will significantly reduce the volume of sludge, destroy pathogens, ensure that toxic metals are not a problem, reduce toxic organic compounds, and ensure that sludge disposal does not present a threat to ground water, the environment, and public health. To support EPA's regulations, research will focus on sludge use criteria, procedures, and requirements applicable to the regulatory process. EPA will refine methods to assess sludge disposal options, including research into ecosystem resiliency or stress resulting from disposal and methods to predict human health effects from exposures to sludge.

Research on potential human health effects from sludge disposal involves collecting data on various chemical and bacteriological contaminants in sludges and sludge products and developing hazard indices for effects associated with different exposure pathways. Studies have been initiated to evaluate health hazards from exposures to sludge where composted sludge is sold as fertilizer. Results from these and other studies will provide data for determining the effects of various sludge treatment processes on mitigating disease.

Health assessment profiles will support regulatory decision making on the effective treatment, conversion, use, and disposal of municipal sludge. EPA will develop information on mitigating risk through sludge treatment and on disposal options, and will produce guidelines for conducting health risk assessments of sludge disposal. Research results will be used to calculate indices for cancer and oral chronic toxicity related to hazards in the food web and inhalation and aquatic toxicity associated with the incineration and ocean disposal of sludge.

The Agency will continue to maintain and update the existing gas chromatography mass spectrometry (GC MS) tape library and will develop new analytical data bases of toxic pollutants found in industrial wastewaters.

Research on sludge stabilization, pathogen reduction, and dewatering offers a major opportunity to reduce substantially costs associated with sludge processing while incurring minimal environmental impact. Pilot- and large-scale combinations of activated sludge and anaerobic digestion to determine the mass and volume-reducing capabilities of the system will be evaluated, along with promising methods such as mechanical composting and conversion of sludge to fuel. Engineering research addressing sludge applications in agriculture, forests, landfills, and land reclamation is needed to establish safe application rates and management techniques and to minimize surface and ground-water impacts.

Innovative/Alternative (I/A) Technology: EPA will provide technical and program support to states, municipalities, consultants, and equipment manufacturers in the areas of facility plan reviews, emerging technology assessments, technology evaluations, small wastewater flow technology, and technology transfer. Also, promising wastewater treatment processes that have had limited full-scale application will be assessed.

Upgrading and Correcting Designs: The Agency will provide information to municipalities to upgrade existing plant capabilities and achieve compliance with minimal capital costs. Research in this area encompasses evaluation of high biomass systems, enhanced oxygen transfer, and second generation nutrient control schemes.

Toxics Identification: EPA will identify and determine distribution of unlisted chemicals in industrial wastewater. Computer programs will be developed for searching stored GC/MS data from industrial wastewater samples for non-priority pollutants; mass spectra will be compared with library spectra for compounds that elude identification by spectra matching; these will be identified by reanalyzing samples using multispectra techniques.

Toxics Treatability and Toxicity Reduction: EPA will evaluate the fate and effects of toxic pollutants in municipal wastewater treatment systems as a component of efforts to develop enhanced control of toxics in such systems. The Agency will also develop toxicity reduction evaluation procedures for municipal and industrial wastewater treatment plants in support of water quality based permit limitations.

Water Quality Planning and Regulation Support: EPA will provide engineering data and managerial techniques necessary for states to apply a cost-effective systems

engineering approach to implement wasteload allocations within their water quality control programs. This will provide more reasonable margins of safety in determining allowable stream loadings and reduce over-design of advanced treatment plants.

Quality Assurance: EPA will continue the quality assurance and repository samples program. The performance of major NPDES dischargers' laboratories will be evaluated, and actions on NPDES alternate test candidate procedure applications will be recommended.

Drinking Water Technology

What new technologies are needed to continue to assure the safety of drinking water?

EPA's drinking water technology research program provides engineering data to support the development and revision of drinking water regulations as well as engineering information and technological support to states, municipalities, EPA regions, and utilities concerned with drinking water regulations and compliance. Major technological problems include the relationship between treatment strategies and deterioration of water quality within the distribution systems, other factors causing deterioration within distribution systems, and the need to bring small systems into cost-effective compliance. A related concern is the impact of distribution system corrosion on drinking water quality and the need for low-cost techniques to solve this problem.

Disinfection Byproducts: Research will continue on improving the knowledge of a number of unidentified by-products produced by chlorination as well as byproducts of alternate disinfectants to chlorine. Evaluations of trihalomethane (THM) control using alternative disinfectants and treatment modifications will continue.

Overall System Integrity: The persistence and regrowth of organisms in distribution systems are influenced by the physical and chemical characteristics of the water, system age, pipe materials and the availability of suitable sites for bacterial colonization. Investigations will also be carried out on other key factors that influence microbial regrowth, such as nutrients, temperature and sediment accumulations. Theoretical, laboratory and field studies will define factors associated with distribution system repair and replacement criteria. Laboratory and field studies will evaluate the impact of changes in treatment and disinfection practices brought about by existing and new regulations.

Small-System Compliance: EPA is directing special attention to small drinking water systems and their compliance with regulations. Research is evaluating the cost and engineering feasibility of specific treatment techniques to remove or control chemical, particulate, and microbiological contaminants. Several evaluations will be at pilot- or full-scale. Laboratory studies are defining variables that govern the effectiveness and efficiencies of treatment processes prior to large-scale evaluations.

Monitoring and Quality Assurance: The Drinking Water Technology Research Program oversees the Agency-wide mandatory quality assurance program for drinking water. Ten regional laboratories are involved in the National Interim Primary Drinking Water Regulations laboratory certification program. Monitoring activities will also develop methods and total measurement systems for precise chemical, microbiological, and radiochemical analysis. This will provide accurate and cost-effective analytical procedures to monitor contaminants for use by the Agency, states, municipalities, and operators of public drinking water systems.

Drinking Water Health

What are the health effects from exposure to chemical and microbiological contaminants found in drinking water?

EPA is required to develop national drinking water standards for contaminants that may cause an adverse health effect. Research to determine the effects and risks from exposure to drinking water contaminants is an essential step and has been explicitly recognized by a provision of the Safe Drinking Water Act. Such research will be continued.

Health Effects Data and Risk Assessment: Toxicological research to develop dose/response data will support development of Maximum Contaminant Levels and goals for disinfectants and disinfectant byproducts, synthetic organic chemicals, inorganic chemicals, radionuclides, and microbes as required under the Safe Drinking Water Act Amendments of 1986. Risk assessments and criteria documents will be developed for drinking water contaminants. Epidemiological studies will determine the associations between drinking water disinfection and cardiovascular disease, and drinking water quality and bladder, kidney, liver, and colon cancer.

Methods Development: Research will be conducted to improve extrapolation of toxicological data from high to low doses and from laboratory animals to humans. The effects of different exposure pathways are being evaluated to improve the accuracy of risk assessments. Microbiological methods are being developed to identify infectious disease agents in water and determine the significance of the occurrence of these agents in water supplies. Methods to determine exposure and risks from chemical mixtures are also being developed.

Ground Water

What is needed to improve the scientific capability to monitor, predict, and clean up ground-water contamination problems?

EPA and the states have a number of mandates for protecting ground water, and almost every regulatory and enforcement program in the Agency has some interest in ground-water protection. In response to these needs, EPA's ground-water-related research programs cover source control, monitoring methods, analytical methods and quality assurance, prediction and resultant assessment of risks, drinking water treatment and health effects, and cleanup methods for contaminated soils and ground water. This section focuses on: wellhead protection, monitoring technology, prediction and assessment tools, underground injection control, aquifer cleanup, and technology transfer. These topics are also funded and conducted in the Hazardous Waste/Superfund and the Pesticides/Toxics areas but are not covered under those sections in this Research Agenda.

The research will be used to evaluate the ground-water flow and fate and transport models available for wellhead protection and delineation. Approaches will be developed for assessing critical delineation factors such as the radius of pumping influence around a well, the depth of drawdown of the ground water supplying wells, and the time and rate of travel of contaminants in various hydrogeologic settings. In addition, the research would provide analyses of the threats to wellhead protection areas from sources of contamination and would evaluate the technical and institutional effectiveness of control methods on the prevention of ground-water contamination in those areas.

Predictive Methods: Predictive research provides the basis for assessing the risk of ground-water contamination upon drinking water supplies and for understanding subsurface processes that may eventually lead to cleanup

methodology. Sorption, biotransformation, transport, mixed solvent interactions, oxidation reduction, hydrolysis, dechlorination, dispersion, fractured flow, and immiscible flow will be investigated for organic chemicals that could pose significant risk. Research will continue on virus survival and transport, and metals mobility. Contaminant-transport models will be adapted and modified to include the improved process descriptions. Field evaluations will determine the degree of confidence that can be expected from predictive models in various hydrogeologic environments. Applications of models for wellhead protection programs will be evaluated.

Monitoring Technology: EPA's research will improve cost-effectiveness and accuracies of monitoring in three areas: methods, geophysical techniques and interpretive analysis. Sampling and well construction methods will be evaluated to determine their effects on the accuracy of results. Fiber optics technology will be used for inexpensive and reliable ground-water monitoring.

Current methods will be adapted for use on underground storage tanks and non-hazardous landfills. Vadose zone (unsaturated) techniques will be evaluated for their applicability to various situations and soil-gas monitoring will be developed into an inexpensive and reliable method for plume delineation.

Geophysical methods adapted from the energy and minerals resource industry will be evaluated for their applicability to such ground-water contamination problems as detecting leakage from underground injection wells, location of abandoned wells, and contaminant plume detection. Quality assurance methods will be developed and standardized to improve confidence in these techniques.

Interpretive analysis will be used to obtain more information from monitoring data and to improve reliability. Efforts will continue to determine the completeness of coverage for methods to locate abandoned wells. "Variance analysis" will be applied to determine the frequency of sampling required in monitoring wells to gain the appropriate confidence under differing circumstances. A strategy will be developed for monitoring in wellhead protection areas. Finally, geographically based information systems will be used to make ground-water monitoring data more useful to decision makers.

Underground Injection Control: This research will be extremely important over the next few years due to the regulatory requirements of the Hazardous and Solid Waste

Amendments of 1984. EPA is required to reconsider the safety of underground injection as a hazardous waste disposal method and to ban such injection should there be migration out of the injection zone. EPA has a number of research activities under way to aid the Office of Drinking Water in making these determinations, including determining the fluid movement from wells, describing the interaction of injected fluids with the geological strata, and characterizing saline formations in the Texas Gulf Coast as receptors of hazardous wastes. Research will focus on methods to test the mechanical integrity of wells, to locate abandoned wells, and to control practices associated with shallow, non-hazardous injection wells.

Aquifer Restoration: Aquifer cleanup research will provide cost-effective methods for cleanup of contaminated soils and ground water. Alternatives are needed to current approaches such as withdrawal and treatment or containment. Promising laboratory methods for enhancing subsurface biotransformation will be field tested, and the safety of using genetically engineered organisms for biodegradation will be determined.

Technology Transfer: Information transfer will continue to be an important part of ground-water research. Specific training materials are under development in addition to technical assistance to the EPA regions and the states. Direct training of regional and state personnel will continue, and the International Ground-Water Modeling Center, a clearinghouse for ground-water models and training, will continue to be supported. In addition, Technical Assistance Documents will be prepared for use by states in the development and implementation of their Wellhead Protection Program.

Summary of Long-Term Trends

Most of the water research issues described in this chapter will continue into the next decade, with gradually changing degrees of activity and emphasis. Better analytical capabilities will continue to improve the ability to measure trace constituents in water, resulting in better identification of greater numbers of potentially deleterious chemical contaminants. With more toxicological and epidemiological information, water quality managers will face increasingly difficult decisions involving the environmental significance of complex mixtures of pollutants.

A significant near-term issue includes the development of toxicant information for complex mixtures. The growing inventory of chlorinated organic contaminants in complicated combinations requires significant changes in

the research strategies and technological methods used to assess them. Whole-sample evaluations such as matrix bioassays, biological indicators, and chemical surrogates will play a larger role in the future. To remain responsive, EPA's water research program must simultaneously develop and validate new methods for evaluating complex mixtures and their impact when applied in regulatory situations.

The environmental water quality issues, including estuary protection, ocean disposal, and the water quality based approach, all reflect the emerging need to develop new tools to test and monitor ecological impacts such as effects on the community at a system level. In ensuing years, major strides will be made in identifying safe or "no-effect" levels of toxic organic contaminants in sediments and water and in methods to establish biological availability and bioaccumulation in tissues of aquatic organisms.

Many communities and landowners rely upon ground-water sources for drinking and irrigation. Questions regarding the quality of ground water have been increasing in recent years. Consequently, the dynamics of ground water and the residence times and fates of leached contaminants in aquifers will be a major water resource issue for the remainder of the century. The coming years will see the refinement of the capability to simulate and predict the impacts of contaminants on underground sources, and cleanup technology will become more important.

In the wastewater treatment areas, emphasis will be on control of toxics in wastewaters and sludges. Improved engineering and the periodic emergence of innovative and alternative technologies may reduce costs. A major breakthrough in wastewater treatment may come from biological engineering, possibly through the development of organisms that could be more effective in treating wastewater and sludges than other methods.

Resource Options

1988 Current Estimate: $ 47.2M
1989 President's Budget: $ 47.1M

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	47.1	47.1	47.1	47.1
Moderate	48.5	50.0	51.5	53.0
High	50.0	51.5	53.0	54.6

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional emphasis would be given to research on wetlands, pollutant fate and effects in ground water, sludge, estuaries, and near coastal areas. In addition, efforts would be directed towards developing techniques to quantify health risks from exposure to complex mixtures and to augment the drinking water repository samples and quality assurance programs.

High: The research cited under the moderate growth option would be augmented and accelerated, and additional research on water quality criteria would be conducted.

Pesticides/Toxics

Pesticides and toxic substances research provides support to meet the current and future needs of the Toxic Substances Control Act (TSCA); the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Asbestos Hazard Emergency Response Act (AHERA); to some extent, the Federal Food, Drug and Cosmetic Act (FFDCA); and the Superfund Amendments and Reauthorization Act (SARA). Research efforts are geared toward providing scientifically valid yet cost-effective methods for evaluating the risks associated with pesticide uses and the manufacture, use, and release to the environment of new and existing chemicals.

The research program in support of the above acts will continue to develop, evaluate, and validate health, exposure, and environmental test methodologies and procedures to improve the predictability of human and environmental risk estimates and to develop exposure monitoring systems, environmental fate and effects methods, and guidelines to perform ecological risk assessments. Additional research will develop and evaluate release and control methods for new and existing chemicals, structure activity relationships as predictors of chemical fate and biological effects, and procedures for ensuring the human and environmental safety of the products of biotechnology. Field validation studies and contamination of ground water from pesticides are other areas of interest in the ongoing research program.

Major Research Issues

Test Method Development

What new procedures or tests are needed to ensure that industry's data on environmental or health effects are accurate, reproducible and consistent?

Under TSCA and FIFRA, manufacturers must test chemicals and pesticides for potential hazards to public health and the environment. Consequently, research is conducted to develop standard methods, to develop or evaluate improved, more cost-effective methods, and to provide quality assurance materials for performing such tests. Regulatory decisions on a chemical depend on qualitative and quantitative scientific data from industry regarding potential adverse environmental and human health effects of exposure to the chemical.

Scientific assessment efforts in the test method development area will focus on research activities to

improve the Agency's ability to assess exposure to and potential health effects associated with the use of pesticides or the manufacture, production, distribution, use, or disposal of chemical substances or mixtures. This research is largely focused on data inadequacies identified in the course of scientific assessment of chemicals during regulatory analyses performed by the program office and coordinated with ORD. These research activities involve issues critical to the assessment of exposure and various adverse effects (carcinogenicity, developmental toxicity, reproductive effects, other chronic effects, and the estimation of heritable risk at low doses). Information from these assessments will be included in the Integrated Risk Information System (IRIS).

The monitoring program will focus on the development of quality assurance materials research on exposure to assess chemical residues in humans, in human tissue and fluid, in the environment, and in biota. In this area, research will be conducted to develop total human exposure methods for identifying chemical compounds. Bioassays using monoclonal antibodies and biomarkers such as enzyme induction and protein/DNA adducts will continue to be evaluated as potential screening tools for human exposure. Finally, human exposure methods research will focus on advances in supercritical fluid chromatography, GC and LC/MS analyses, ICAP-MS analyses, and the development of biochemical and immunochemical markers to detect exposure to particular pollutants. Methods and procedures including laser-based, real-time continuous monitors to identify asbestos in indoor air during and after abatement actions will be investigated in support of AHERA. There is a continuing need for research into new and more sensitive analysis methods for various classes of compounds evaluated under FIFRA, TSCA, and SARA programs in both environmental and biological media. Statistical methods to analyze data from complex mixtures will also be developed.

Environmental effects research will evaluate existing methods and perform studies to determine the sensitivity of available tests and identify species for potential future test methods development. Methods are also being developed, validated, and evaluated for environmental toxicity testing. In this area, major advances will be required to relate single-species and microcosm data to actual ecosystem effects and to adequately relate observed effects on one species to probable effects on

other species. Testing applications are designed for assessments and monitoring.

Health effects research efforts are directed toward developing and validating predictive, reliable, and cost-effective in vitro and in vivo test systems. Test methods development will focus on the prediction of toxic hazards in the following areas: reproduction/teratology, neurotoxicity, immunotoxicity, genotoxicity, and carcinogenicity for inclusion in test guidelines to be used by pesticide registrants and in Section 4, TSCA testing requirements.

Structure Activity Relationships (SARs)

What information needs to be developed on substances and their similarity of chemical structure to determine the additional testing needed to assure the safety of humans and the environment?

To enhance the efficiency of the regulatory process for toxic substances, it is convenient to group various chemicals that share common or similar chemical characteristics rather than to deal with each individual chemical. If it can be demonstrated that chemical relationships, such as similar molecular structures and similar modes of toxic activity, form a firm scientific basis for estimating probable environmental risks, then better guidelines and techniques can be applied and regulatory actions can be completed more quickly using fewer resources. This approach will provide both the regulator and the regulated a standard basis for determining if a substance might be toxic and detrimental to living organisms or their environment.

SARs are important for reviewing and screening PMN chemicals under Section 5 of TSCA. The findings and techniques established in this research will be used to select appropriate toxicity tests, to document test results, to develop fate and effects data bases where necessary, and to provide the modeling means to predict toxicity.

Environmental effects research will include data base compilation and improvement in the precision and validation of SARs for predicting toxicity. Studies will include assimilation of fate parameters such as photolysis, biodegradation, and likely metabolites in multimedia matrices. QSAR models are being developed to estimate acute toxicity for fish, chronic ecotoxicity for fish and invertebrates, bioconcentration factors, and log P.

Health research will focus on the development of methods using a combination of descriptors based on molecular structure to predict genetic, carcinogenic, and other toxic

activities through pattern recognition, statistical, and thermodynamic techniques. Data bases containing bioassay data for use in predicting the mutagenic and carcinogenic potential of new chemicals in the environment will also be developed. Quantitative dose-effect data are also developed on specific compounds and classes of chemicals to aid in predicting the toxicity of structurally similar chemicals.

Special Human Data Needs

What effects do specific chemicals have on actual populations occupationally or environmentally exposed to the chemicals?

To improve the Agency's ability to estimate human health risk, these activities will examine population groups exposed to environmental contaminants that are suspect toxicants. Research is continuing to determine whether biological indicators of dose and/or effects are related to environmental levels of exposure and if they are correlated with adverse effects measured by traditional methods. This includes DNA adducts, nervous system specific proteins, and metabolites in blood and urine.

Ecology: Transport/Fate/Field Validation

What methodologies (including mathematical models) are needed to assess the fate and effects of toxic chemicals and pesticides in the environment?

To adequately evaluate the likelihood of perturbations a pesticide or toxic chemical may cause in the environment, it is necessary to understand probable exposure concentrations/durations, movements through ecosystems, degradation rates, reservoirs, effects and residues. The Agency must have available techniques that may be applied to attain this information, and it must be able to interpret findings and prevent problems. Activities in this area are designed to meet these needs, to improve the criteria and standards with which industry, the users, or the Agency must comply. The intent is to provide new or improved state-of-the-art techniques to fill data gaps in order to have scientifically credible and legally defensible regulatory actions.

Research will be conducted to evaluate microcosms at freshwater, estuarine/marine, and terrestrial semi-natural and natural field sites. Multispecies laboratory bioassays will also be validated to allow data bases to be documented and published that may be used to predict the effects of toxic chemicals on aquatic and terrestrial

vertebrates and invertebrates. System level investigations will validate multispecies and community level toxicology methods. Field tests will be conducted to assess the influence of colloidal organic matter on the uptake of chlorinated toxic chemicals by benthic organisms. Finally, field evaluations will be carried out to verify the responses of select organisms to sediment-bound toxics found in freshwater ecosystems.

Efforts in this area will also determine the specific species and testing methods to assess the effects of toxic chemicals on terrestrial, freshwater, and estuarine/marine species to provide data that can be used as surrogate information for other organisms. Evaluations will focus on comparative toxicology correlations and on validating promising correlations. Wildlife species testing will be emphasized to compare with previously conducted laboratory tests. Terrestrial toxicology research will be conducted to validate tests that determine the toxicity of chemicals to different strains and sources of birds.

Pesticide-oriented investigations will focus on representative estuarine, freshwater, and terrestrial field sites and will consider pesticide dose, exposure, effects, and functional alterations at the species/population level. Non-target organism (e.g., fish, invertebrate, crustacean, bird) effects will be quantified in terms of mortality, reproduction rates, and resiliency. This includes residue analysis and population census (pre- and post-treatment) information. Through extensive field sampling, data collection and analysis and simulated exposures, field findings will be compared to lab findings. Final evaluations will be published indicating where lab results are comparable to field results and indicating if hazard assessment criteria are adequate. Additionally, laboratory and field studies will determine the relationships among the use of pesticides and other agricultural practices, pesticide characteristics and field conditions and resultant pesticide concentrations in ground water to mitigate ground-water contamination problems.

Transport and fate processes and exposure information are highly critical to the Office of Pesticides and Toxic Substances (OPTS) operations. Various laboratory tasks will contribute exposure information based on such parameters as sorption kinetics in sediments, pesticide transformation, biodegradation, and movement in the environment. Rate constants will be derived and the extent of chemical reactions determined in order to describe mathematical expressions that will lead to estimates of exposure concentrations. Mechanisms and

rates of degradation by natural microbial communities will be studied. Controlling environmental conditions and processes affecting degradation will be determined, and quantitative relationships between the pesticide chemical characteristics and the environmental parameters will be factored in.

Field evaluations of methods and exposure models (with emphasis on leaching models) will be conducted through laboratory and field studies, including analyses of residues in soils. This includes information generation on the variability of soil water releases and ground-water contamination and on model calibration and improvements to predict exposure concentrations and toxicant movement. Appropriate workshops and symposia may be convened to transfer results to users. When developed and evaluated, these models will predict the environmental impact of pesticides and toxic substances.

Health: Markers, Dosimetry, and Extrapolation

How do we relate external dose to internal dose and to early indicators of disease states and how can we better extrapolate (from high dose to low, from differing routes of exposure, and from laboratory animal to man) to support risk assessments?

For both the pesticides and toxic substances programs, health effects research will be focused on developing methodologies for extrapolation of animal data from high to low doses, between mammalian species, and between different routes of exposure to reduce the uncertainties in human health risk assessment. Additional studies in the toxic substances research program involve defining the relationship between environmental exposure, internal dose, and biological response in clinical and laboratory studies. Pharmacokinetic studies will be carried out using dermal and inhalation routes of exposure. Additional pesticides research includes evaluating the relationship(s) of age and dermal absorption using in vivo animal models as well as research on compound-induced reproductive alterations following exposure during developmental periods.

In addition, for both pesticides and toxic substances programs, biological markers will be reviewed for their capacity to indicate episodes of exposure. Factors such as the specificity of the biological response to individual chemical exposure and the susceptibility of individuals to biological responses will be investigated.

Exposure Monitoring

What improvements are needed for the monitoring methods, systems, and analysis used to provide the data bases for estimating human exposure?

TSCA-related monitoring efforts will be directed toward improvements in monitoring instruments and systems to estimate human exposure. Research will be continued to develop approaches for multimedia/multipathway monitoring systems using geographic information system (GIS) technology. Studies relating concentrations of volatile organic chemicals in blood to those in breath will be compared. Human exposure monitoring studies will be conducted in a WHO/UNEP Human Exposure Assessment Location (HEAL) Project. Biomarkers will be evaluated as indicators of exposure to toxic compounds. In pesticides, the Non-Occupational Pesticide Exposure Study (NOPES) will continue to be conducted.

Biotechnology/Microbial and Biochemical Pest Control Agents

What methods and technologies are being developed to provide risk assessment data to evaluate microbial agents and other products of biotechnology?

Many of the techniques required to adequately control or regulate microbial organisms or biochemical products (e.g., pheromones) apply to both TSCA and FIFRA mandates. Products of biotechnology used as pesticides are subject to FIFRA; most other biotechnology products (e.g., industrial chemicals, biodegradation products, fertilizers) are subject to TSCA. FIFRA products are evaluated for their environmental effects, as they are designed to be deliberately released. TSCA products are evaluated for their potential health and environmental effects, on the basis of workplace exposure and accidental or deliberate release.

Producers of biotechnology products must follow recommended Agency guidelines in a testing regime designed to estimate potential adverse environmental/health impacts. ORD helps establish these techniques (used to determine if environmental effects on non-target organisms may be anticipated) and conducts field-oriented validation studies to ensure that testing criteria and guidelines are appropriate and functional. Research is also conducted to develop or improve methods to monitor, contain, or destroy genetically engineered organisms in industrial settings. This research will provide the bases for

monitoring guidelines for TSCA PMN submissions for genetically engineered microorganisms.

Under FIFRA, research will develop or improve bioassay methodologies for determining environmental effects on non-target receptors or hosts. This includes providing testing protocols and effects information for unaltered and genetically engineered microbes. Investigations focus on routes of exposure, methods to detect and identify agents, toxicity, infectivity, persistence, gene transfer, and ecosystem effects. This information will be included in Subpart M guidelines and will be used for regulatory decisions.

Pesticides health research in biotechnology involves development of data on the effects of microbial pest control agents on mammalian cells. Immunological methods are being developed using monoclonal antibodies and DNA probes to enable the identification of genetic material from biological pesticides in non-target sites such as mammalian cells. Studies will be conducted to determine the genetic stability and function of a baculovirus expression vector in vertebrate cells. The results of this research will provide the basis for validation of Subpart M guidelines for testing microbial pesticides. Pesticides monitoring research in biotechnology will focus on evaluation of measurement techniques to produce guidelines governing field release of genetically engineered microorganisms.

Under TSCA, efforts will continue to evaluate, develop, and standardize scientific rationales, procedures, and instruments to monitor the environmental survival, reproduction, distribution, effects, and risks associated with the release of genetically engineered organisms. The impact of genetically engineered organisms on the rate of gene transfer in the normal mammalian gut flora will be studied to determine the potential for adverse health effects. The results will be used to prepare protocols and quality assurance guidelines for use in evaluating the impact of released microbes. This research will support the development of field test requirements for release of genetically engineered microbes into the environment.

Engineering Release and Controls

What engineering and technological information is needed to predict the release of and exposure to toxic substances and to determine alternatives for control of these substances?

Under the premanufacture notification (PMN) process, manufacturers are required to submit information to EPA on the release and control of new chemicals and significant new uses of existing chemicals. EPA uses existing data and methodologies to predict the risks associated with the release of new substances, and, under the existing chemicals control program, evaluates technological alternatives to reduce the release of and exposure to chemicals that are already in use.

Models will be developed which predict the release of and exposure to classes of new chemicals in order to assess chemical-unit operations and processes, and the physical and chemical properties of chemical substances. Additionally, models to predict potential exposure and release levels, and the best measures to control release of and exposure to new chemicals will be developed. Treatability testing of potentially toxic chemicals will also be conducted.

Alternatives to mitigate the release of and exposure to specific existing and new toxic substances will be defined through the evaluation and adaptation of existing control measures. Technologies, management practices, and personal protective equipment to limit release and exposure will be evaluated and methodologies developed to test their effectiveness. For asbestos, in addition to evaluating control technologies, research will include characterizing durable replacement fibers and evaluating the long-term effectiveness of removal technologies and decontamination procedures.

Under FIFRA, EPA is responsible for pesticide exposure studies, for reviewing and approving pesticide labels, for administration of the pesticide Farm Safety Program, and for supporting training and education programs for pesticide users through state extension services. The Agency is concerned that protective clothing currently recommended for pesticide users is not providing acceptable protection. This situation is aggravated by a lack of appropriate data. EPA is therefore requiring greatly improved documentation about the effectiveness of protective clothing. This program will focus on generating breakthrough time and steady-state permeation rate data for concentrated formulations of high-toxicity pesticides

through a range of commonly available polymer gloves that may be suitable for use by mixers and loaders of pesticides. Evaluations of the job compatibility and degree of protection provided by clothing items other than gloves will also be conducted via laboratory and field testing.

Ecology: Ecotoxicity and Risk Assessment

What methods are needed to evaluate ecosystem risk as a result of exposure to existing and new chemicals?

In the past, ORD's scientific assessment program has emphasized the assessment of risk to human populations. However, the risk to non-human populations and the environment also needs to be assessed. The development of ecological risk assessment protocols and guidance for terrestrial and aquatic ecosystems is necessary to quantify the probability that adverse effects may occur as a result of exposure to a toxic substance and to estimate the significance of such effects in the environment. Since release, use, and disposal patterns of environmental data developed by industry may vary greatly from chemical to chemical, procedures need to be developed which offer guidance and consistency for the various environmental exposure activities. This work will provide risk assessment protocols and guidelines for the assessment of effects to terrestrial and aquatic ecosystems.

Ecosystem risk research will provide a scientifically based system to assess ecological risks from exposure to environmental toxicants. This system will have the capability to assess risks associated with different uses of chemicals that result from considering various options for regulating pesticides and toxic chemicals to protect organisms in their natural environment. This research will provide for prognostic assessment, extrapolations to any patterns and levels of environmental release, inferences of types of responses to be expected in natural systems, and estimates of uncertainties in the assessments. Finally, it will integrate chemical fate, exposure, and effects to enable the user to conduct risk assessments for terrestrial and aquatic systems.

This information will be integrated through a computerized framework linking all components to facilitate appropriate analyses and produce results in any desired form. The studies will include data bases of scenarios such as river reaches, endangered species habitats, chemical properties, and characteristics of organisms including geographical range and habitat preferences. Activities will

utilize and develop traditional analysis techniques and models that calculate bioconcentration and effects for populations, communities, and ecosystems and provide quantitative and qualitative probability statements of uncertainties involved in the assessments.

Support

What support is required for preparation and review of scientific assessments and for quality assurance?

For certain assessments, the technical expertise of the ORD staff is used to interpret data or provide technical and scientific opinions and judgments. In cases where program office evaluations are complicated and/or controversial, independent peer review of assessments is used to ensure consistency. There is a continuing need for ORD participation in and review of major exposure and hazard assessments conducted by OPTS, for supplying Agency policy makers with technical assistance from qualified scientists, and for improving the scientific basis of Agency decisions in regulatory matters.

When requested, ORD will provide critical review of test rule documents for existing chemicals. Such activities will support validation of toxicity tests and will assist with exposure and risk assessments and with preparation and update of TSCA testing guidelines. This support will also encompass evaluation of complex problems associated with environmental fate, hazards, and risks of toxic chemicals and bioengineered organisms as necessary for implementing TSCA.

ORD also advises OPTS on the development and implementation of laboratory qualification programs to identify asbestos in the environment, provides chemical reagents and quality control samples for use in TSCA and FIFRA monitoring schedules, and provides guidelines for applying models in exposure monitoring under TSCA.

Finally, in both the pesticides and toxics areas, support will continue for quality assurance and maintenance and dissemination of standard reference materials.

Analytical methods will be evaluated and standardized for chemicals reviewed under SARA. Guidelines for sample collection, laboratory preparation, and analysis will be prepared, and methods will be developed, where necessary, for chemical analyses in specific media.

Summary of Long-Term Trends

Pesticides and toxic substances research efforts focus on both intentional and unintentional releases of chemical substances into the environment. Each of the issues covered in this chapter will continue into the next decade. Various degrees of emphasis are addressed below:

Test method development efforts will continue in support of both TSCA and FIFRA guidelines. As current methodologies are standardized, new techniques will be developed to fill gaps in existing methods. These new methods will focus mainly on endpoints other than carcinogenicity and will provide more effective means to conduct quantitative risk assessments. To this end, efforts will increase for developing extrapolation techniques (from high to low doses and from animals to humans) that reduce the uncertainty of laboratory data used in predicting human risk. The development of biological markers will also assist in this area by providing more accurate measures of human exposure levels as well as serving as tools for epidemiological studies. Concurrently, the development of exposure monitoring systems will increase to provide new monitoring methods, systems, and analyses to more accurately characterize human activity patterns and total human exposure.

Ecological risk assessment research will continue to develop methods and models for determining the fate and effects of chemicals. These exposure methods and models will provide the means to evaluate risks. The integration of such methods and data will enable the development of protocols for environmental risk assessments. Ecological research will continue to validate fate, transport, and effects techniques and applicable testing guidelines required by the Agency for scientific credibility and defensible regulations.

Research to provide information on the release and control of new and existing chemicals from manufacturing processes will allow the rapid and accurate prediction of how much and where chemicals will be released into the environment, and with increasing accuracy, an estimate of associated exposure. Treatability of chemical wastes and degradation products will be better defined to improve characterizations of risk. Such information is vital to the PMN review process, and it is anticipated that the need for such data will continue to increase as the manufacture of new chemicals continues to grow.

EPA will provide methods to protect public health and the environment from the potential adverse impacts of microbial agents and the products of biotechnology. This research will help to determine containment facilities for bioengineered organisms, means of monitoring the survival and distribution of those intended for release, and controls for inadvertent releases.

The structure-activity research program will continue as methods for predicting fate and effects of primary and degradation compounds become available, and the need for field validation efforts will increase to ensure the reliability of methods used to test chemicals.

Resource Options

1988 Current Estimate: $ 39.7M
1989 President's Budget: $ 41.0M

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	41.0	41.0	41.0	41.0
Moderate	42.2	43.5	44.8	46.1
High	43.5	44.8	46.1	47.5

No Growth: Established priorities would continue to guide the research.

Moderate: Moderate growth would allow the current base program to continue and enable the Agency to enhance and expand studies in priority areas.

High: With high growth, ORD would expand into additional areas not currently funded (i.e., SARA Title III).

Hazardous Waste/Superfund

The Resource Conservation and Recovery Act (RCRA) authorizes a regulatory program to identify wastes that pose a substantial hazard to human health or the environment and develop waste management standards that protect human health and the environment. Research support for this program provides the scientific and engineering basis for characterizing wastes, determining the hazards they pose, and formulating controls. In addition, Section 311 of the Clean Water Act authorizes research to support prevention and control of hazardous materials releases.

The Office of Emergency and Remedial Response (OERR) requires scientific research and technical support from the Office of Research and Development (ORD) to investigate and mitigate health and environmental problems at the priority sites listed under authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). ORD's research program provides a core of scientific and technical information to support the implementation requirements of CERCLA and the enforcement actions undertaken to obtain cleanup and recovery of costs. It concentrates on assessing health and environmental risks posed by Superfund sites and on evaluating equipment and techniques for discovering, assessing, preventing, controlling, removing, and ultimately disposing of hazardous substances released into the environment. Research and support activities consist of programs to develop and evaluate the validity of methods for detecting and evaluating adverse human and environmental effects, to evaluate alternative control and removal technologies, and to develop effective monitoring systems.

The ORD program for Superfund is intended, among other things, to respond to new authorities that enhance the Agency's internal research capabilities related to Superfund activities and is also focused on responding to more comprehensive site-specific evaluation needs for Superfund sites. Plans provide for increased site-specific assessments, quality assurance, and technical support for the monitoring program; increased technology transfer activity; increased innovative alternative treatment and detection technology research, development and demonstration programs for both monitoring and engineering; expanded research on health effects, health risk assessment, and increases in the support to Regional Offices for risk assessment activities; increases in support to the

Regional Offices in the areas of ground-water sampling, analysis, and data interpretation by the multidisciplinary ground-water support team.

Major Research Issues

Alternative Technologies

What information and data are needed to support and permit the use of alternatives to land disposal?

The Agency is implementing the program that will ban land disposal of certain classes of untreated hazardous wastes. Banning these wastes could require the availability of proven alternatives for treating or recycling waste materials. Although many of these technologies currently exist, many questions are asked about their effectiveness on specific wastes and their capacity to address the anticipated volumes that will require treatment. This research will provide support for the Office of Solid Waste (OSW) in implementing the portions of the RCRA amendments which require banning certain hazardous wastes from land disposal.

Research on alternative technologies assesses the performance of the major alternatives now under development, and in selected instances supports the evaluation of processes found by the Agency to offer substantial improvements over conventional hazardous waste disposal methods. Such evaluations will be conducted and used with existing data to form the basis for treatment standards.

Assessments of alternative technologies are conducted at bench, pilot and field scales with emphasis on waste streams assigned high priority by OSW. Included will be aqueous waste streams from the chemical industry that are likely to be banned from landfills and wastes with a high potential for volatile air emissions.

What technologies are appropriate to clean up priority sites?

The ORD program for Superfund will be expanded from its start-up level to implement an innovative/alternative treatment technology demonstration program at the level authorized by the Superfund Amendments and Reauthorization Act. The Agency will conduct 10 demonstrations per year to accelerate the commercialization of innovative/alternative treatment technologies that will clean up priority sites.

Engineering evaluations of emerging technologies to accelerate private development will be increased.

Technologies to be developed will continue to be selected from applications submitted to the Agency in response to solicitation in the Commerce Business Daily. The focus will continue to be in the areas of recycling, separation, detoxification, destruction and stabilization that promise significant new methods for cleaning up Superfund wastes.

This activity will also provide increased testing and evaluation of newly developed but unproven innovative monitoring techniques for applicability to Superfund monitoring situations. In addition, promising advanced/innovative monitoring techniques and systems which are not yet ready for demonstration will continue to be further developed so that their utility for Superfund pollutant characterization can be demonstrated.

The technical improvement of commercially available or prototypical protective clothing, equipment, and procedures for use in responses at Superfund sites will continue to be identified, evaluated, and promoted. Reports on personnel hazard detectors, personnel cooling devices, vital signs monitors, intra-EPA and interagency workshops will be provided.

Technology-specific evaluations for Superfund will continue to be provided in the major technical areas of in-situ and on-site treatment. The emphasis will be on providing engineering information for the remediation process. In addition to activities on extraction, detoxification, and immobilization processes, new efforts will include identification, at laboratory and pilot scale, of processes most suitable for soil fractionation in the field, as a function of the type and particle size distribution of soils. Such techniques would help in minimizing on-site treatment and disposal costs.

In microbial clean up (biosystems), technologies will continue to be applied and evaluated for use in program office responses to Superfund sites. The emphasis will be on the use of techniques to enhance the metabolism of hazardous substances by indigenous microorganisms and the use of specially engineered microorganisms at actual field sites. Such techniques are potentially more effective and less costly than currently applied clean up methods.

Site Assessment and Support

What information and technical support is available for site-specific risk analysis and risk reduction?

For SARA, this program will also continue to provide site-, situation- and chemical-specific exposure and risk assessments to assist the program office and regions in evaluating the degree of hazard at uncontrolled waste sites. Specific activities will include preparation of site/situation-specific risk assessments, rapid response health assessments, Health and Environmental Effects Documents, and Toxicological Profiles for use in Remedial Investigation/Feasibility Studies (RI/FSs) and other remedial planning efforts.

For SARA, this activity will continue to generate chemical-specific carcinogenicity and chronic effects documentation to support the program office's regulatory process, which lists substances as CERCLA "Hazardous Substances" and calculates or adjusts their Reportable Quantities (RQs). This support will allow the Agency to continue the normal RQ adjustment activity, to complete adjustments pursuant to the additional requirements placed upon the Agency by the Superfund Amendments and Reauthorization Act of 1986, and to consider other chemicals for listing as CERCLA Hazardous Substances and for calculation of RQs. Finally, review of previously calculated RQs will be performed on request from the program office or when significant new data become available.

With the acceleration of clean up activity, in general, a significant increase in enforcement activity is expected. This will increase the need for endangerment assessments. Site- and chemical-specific health assessments will be prepared to respond to those needs to assess endangerment at Superfund sites where Enforcement has the lead for implementing remedial responses. Assessments to be provided will range from brief hazard summaries to many detailed, peer-reviewed endangerment assessments for use in negotiations or litigation with potentially responsible parties. The new effort on review of regional risk assessments will continue. This will include providing a central point for coordinating review of regional risk assessments and establishing a focal point for regional offices to request risk assessment assistance.

Increased resources will allow enhanced efforts to evaluate, validate, standardize, and field test monitoring techniques to support program office monitoring at sites.

Analytical methods for hazardous substances at sites will continue to be validated for Superfund waste matrices.

Site-specific monitoring support will provide aerial imagery and photographic interpretation and other technical support to OWPE, OERR, and the regions for use in pre- and post-remedial site assessment. Geographical information systems will generate data for analysis of present and historical site operations and conditions at waste sites. Air monitoring techniques will be evaluated to provide source monitoring methods at sites.

Engineering expertise will continue to be provided to assist the program office in RI/FS of specific Superfund sites during efforts to plan responses. Updated RI/FS treatability and cost estimation information will continue to be provided.

The engineering program will continue to advise and consult with the program office on technical issues that arise during emergency and remedial responses at Superfund sites and will offer support to Enforcement for cases under way.

Technical support will continue to be provided in response to specific requests from OWPE, OERR, and regions on ground-water sampling, analyses, data interpretation, and site assessment and remedial action issues. Increased emphasis will be given to the application of bioassessment techniques for determining acute toxicity and bio-availability of Superfund wastes, extent of contamination, and remedial action progress, and in transferring this technique to others in the public and private sectors. Other activities will include: the application of assessment methods to determine the appropriate control technology for minimizing the risks from contaminated marine sediments, which is important for limiting the uptake of hazardous materials by marine organisms and their impact on humans through the food chain; the application of emerging biotechnology techniques to Superfund sites for improving in-situ cleanup through biodegradation processes (biosystems); and the application of multimedia exposure/risk assessment methods to Superfund sites.

An increased level of technology transfer assistance in issues relevant to Superfund cleanups will be provided to the program office, regions, and states.

Hazardous Substances Research

What research information is needed to assess health risks from hazardous substances?

Research to support health risk assessment data generation and methods development will be provided in this program. Efforts will be expanded in research to understand risks posed to reproductive health resulting from exposure to chemicals, on development of risk assessment methods, on development of exposure information obtained and applicable in the field, on the development of pharmacokinetic methods, on development of micro-computer-assisted risk assessment tools, and on methods to better characterize the risks from chemical mixtures. Work will begin on evaluating the role of promoters found at waste sites in carcinogenesis on developing biologically based dose-response models, and on improving techniques for route-to-route extrapolation.

In the new health effects research program, emphasis will be on neurotoxicity and reproductive effects. New research will be initiated on the health effects of toxicant combinations and complex mixtures in ground water, on development of statistical methods for dealing with complex toxicological interactions, on the importance of using human metabolism data in animal-to-human extrapolation of toxicological data, and on identification and use of genetic and dosimetric markers for human exposure to hazardous substances.

Development and validation of promising field screening techniques having potential to provide improved Superfund pollutant characterization will be pursued. Monitoring technologies such as x-ray fluorescence, fiber optic sensors, portable gas chromatography, and immunoassays offer the possibility of field utility, thereby significantly decreasing the time required to characterize pollutants. In addition, increased efforts will be expended in development of monitoring systems that are useful in integrated multimedia health assessments.

Waste Characterization

What health and risk assessment information and procedures are needed to characterize wastes and assess the hazards they represent?

Assessing the risks associated with various methods of waste disposal is a critical aspect of the Agency's RCRA program but is an area of major scientific uncertainty.

Developing the scientific and technical information needed to establish the quantity and types of wastes that escape into the environment through different disposal methods, the effects they produce for both human health and the environment, and the methods for assessing their risks will remain a significant area for research activity for some time. Moreover, given that most existing information is based on the properties of individual chemicals, rather than the complex mixtures of chemicals typically found in wastes streams, the state-of-knowledge in this area will require several years to develop.

Increased research to support health risk assessment data generation and methods development will be provided in this program. Efforts will be expanded in research to understand risks posed to reproductive and developmental health resulting from exposure to chemicals, on development of risk assessment methods, on development of exposure information obtained and useable in the field, on the development of pharmacokinetic methods, on development of micro-computer-assisted risk assessment tools, on integrated exposure assessment, and on methods to better characterize the risks from chemical mixtures. Work will begin on evaluating the role of promoters found at waste sites in carcinogenesis on developing biologically based dose-response models, and on improving techniques for route-to-route extrapolation.

The information developed to support this research area will be used by OSW in listing/delisting, permitting and enforcement decision making, regulatory policy making, and implementing the land-banning program. Products will provide more applicable, less expensive, and more accurate information and risk assessment methodologies.

A program to develop more accurate methods for predicting the quantity, composition, and volatility of leachates from land disposal of wastes is under way. These and other methods for determining the escape of hazardous wastes into the environment, as well as predictive models in air, surface water, and ground water, will have to be combined into multimedia tools for exposure assessment. Products of this research will be critical for the Agency's land-banning and ground-water programs.

Chemical-specific Health and Environmental Effects Documents (HEEDs) will be prepared to support RCRA 3001 listing decisions. Support will also be provided to

the Agency's effort to ban land disposal of certain wastes and will include evaluation of Reference Doses (RfDs).

Environmental processes research will include development of multimedia assessment models for land disposal sites and ground-water models for predicting waste concentrations. Research addressing complex mixtures will be expanded to allow better characterization of their environmental toxicity for use in decisions on delisting, banning, and permitting.

Dioxin

What assessment information is needed to identify and address the problems associated with dioxins?

Research supporting this objective is intended to help the Agency assess and monitor the dioxin contamination problem and begin developing procedures for addressing it. Although much of the research is completed or nearing completion, risk assessment activities will be continued, as will research on the uptake of dioxins by plants. This research will address uncertainties and fill in data gaps identified in recent revisions to earlier risk assessments.

Waste Identification

What analytic methods are needed for identifying the chemical constituents of wastes and thereby determining which wastes are hazardous?

Additional analytical methods for implementing Section 3001 of RCRA must be standardized and tested to determine their validity and reliability. New methods and procedures for detecting the presence of hazardous wastes under field conditions are also required to help implement Section 3013 of RCRA, which authorizes EPA to establish facility monitoring requirements.

New hardware and software developments offer considerable promise for reducing the costs and time, while improving the sensitivity, of laboratory analyses. Examples of the emerging technologies are supercritical fluids, quadrupole-mass-spectrometry, and thermospray injection. Considerable effort will be directed to evaluating and applying such technologies for hazardous waste analyses. One particular thrust will be in the development of technologies for rapid screening of large numbers of samples, particularly ground-water samples. A second effort will be toward obtaining more comprehensive chemical profiles of volatile and semi-volatile organic chemicals in solids and other complex matrices. Concurrent with these activities will be a continuing effort

to upgrade the computer programs supporting the analytical equipment, with special attention to computer interpretations of measurements.

This program will support activities in the following areas: development of bioassays into a screening protocol for detecting hazardous waste; development of subsurface monitoring and network design protocols for detecting potential ground-water contaminants; validation of published SW-846 analytical methods; and development of new, more cost-effective analytical methods. These will include inductively coupled plasma and high performance liquid chromatography. Additional emphasis will be placed on addressing RCRA subtitle D facilities, and, as part of this, monitoring and quality assurance practices at these facilities will be assessed.

Land Disposal

What technical information is needed to support permitting of land disposal and land treatment facilities, as well as improvements in design requirements?

Research in this area will provide guidance on design, permitting, operation, maintenance, closure and regulation of land treatment, storage and disposal facilities. It will also address controlling air emissions from facilities and include sampling and measurement procedures, evaluation of emission models, and evaluation of control technologies.

Incineration

What technical information and data are needed to support permitting of incinerators and improvements in design requirements?

Results of this research will be used by EPA and other permitting officials to evaluate the acceptability of incinerating particular wastes and in monitoring operating units for compliance with performance requirements.

As the Agency begins banning certain wastes from land disposal, various disposal alternatives will become increasingly popular, including incineration. However, in order to issue permits for incinerators, Regional Offices and the states will require technical information and assistance regarding their performance capabilities. Ensuring the safety of their operation will require that methods be developed to predict their performance, and that their reliability be increased through control of

operational parameters which avoid formation of hazardous byproducts.

Research will continue to produce performance tests on incineration of wastes burned at the Combustion Research Facility. Real-time methods of determining incinerator compliance with permits will be investigated, as will improved sampling techniques for monitoring thermal destruction operations. Guidance manuals for states, regions, and industry will be produced addressing the best practices for burning wastes in industrial boilers, assessing health risks from incinerator operation and from residual wastes, and assessing the impacts on emissions of incineration failures. Bioassays will be applied to generate data for assessing the risk from various burner methodologies. Bioassays for cancer and for non-cancer effects will also be applied. Health effects data and a comprehensive risk assessment methodology for municipal waste incineration will be provided, and full-scale comparative testing of selected air pollution control devices for municipal waste combustion will be conducted.

Releases

What procedures and information are needed to prevent, contain, and clean up accidental discharges of hazardous materials? This research will support both the CWA's releases section and RCRA's underground storage tank (UST) provisions.

Accidental releases of oil and hazardous material to the land and water occur frequently and constitute a significant environmental hazard. Federal, state, and local emergency response personnel require improved technologies for the prevention and control of hazardous material releases to make cost-effective, environmentally sound cleanup decisions.

Geophysical/geochemical sensors and volatile organic emission sensors and sensor placement networks for detecting leaks of hazardous materials from USTs will be developed and evaluated. Test protocols for determining appropriate performance criteria will be developed as well. External monitoring techniques and systems, those noncontiguous to the tank or line, will be evaluated. Approaches will include computer models, physical models, and field monitoring.

Evaluations of leak detection and monitoring methods for USTs will be produced, as will guidance manuals on nondestructive techniques for locating buried tanks and on UST release prevention techniques. A continuing effort

throughout this period will be the evaluation of new technologies for the prevention and cleanup of releases. Innovative new systems will be sought, and if shown to be feasible, field-evaluated.

Quality Assurance

What measures are needed to assure the reliability and consistency of monitoring and analytical techniques and data used in support of the RCRA program?

The purpose of this program is to ensure that data of known quality are used throughout the Hazardous Waste program. Analytical standards and reference materials will be developed for and distributed to all participating laboratories. Quality control and performance evaluation samples are also being developed and distributed to appropriate laboratories. Technical support will be provided to all participating laboratories in the form of instrument calibration assistance and provision of reference materials.

For Superfund, this program will provide quality assurance support to the Agency's Contract Laboratory Program, additional precontract assessment, calibration materials, laboratory performance assessment, and evaluation/improvement of analytical methods.

Summary of Long-Term Trends

Research to characterize the potential exposure and effects posed by hazardous wastes is likely to be an area of significant importance. In order to effectively manage risk, answer the questions and concerns of the public and make the policy choices that will have to be made, more will have to be learned regarding the identity, behavior, and health and ecological effects of hazardous materials released into the environment.

Development and evaluation of alternatives to land disposal of wastes will remain an Agency priority. Research remains in its early stages, and considerably more work is needed before alternatives will be able to satisfy the disposal requirements of large-scale generators. Extensive testing and performance evaluations are needed to make these technologies available, and years of effort will be required. Research will also be accelerated to provide support for the land-banning program and to support RCRA UST provisions.

Emphasis will also continue on research supporting the Agency's ground-water program and on identifying the problems associated with municipal waste combustors.

Ground-water research will focus on determining ground-water pollutant transport and fate and developing the monitoring technology needed to identify problems and measure the effectiveness of mitigation techniques. Applications of biological techniques for site cleanup will be determined. Research addressing municipal waste combustors will identify the pollutants they produce, assess the hazards they may pose, and determine the monitoring and control technologies needed to address the problems. Development of field methods for in-situ analysis at waste sites is planned to continue.

Resource Options

1988 Current Estimate: $103.2M
(Hazardous Waste: $ 44.7M; Superfund: $ 58.5M)

1989 President's Budget: $108.1M
(Hazardous Waste: $41.3M; Superfund: $ 66.8M)

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	108.1	108.1	108.1	108.1
Moderate	111.3	114.6	118.0	121.5
High	114.6	118.0	121.5	125.2

No Growth: The program would proceed as described in this agenda.

Moderate: Additional resources would further support waste characterization activities in support of waste management decisions, ground-water research, treatment technology research, ecological risk assessment, and municipal waste combustion research.

High: Research described under moderate growth would be accelerated and augmented.

Multimedia Energy

The multimedia energy research and development program is designed to provide the scientific and technical information necessary to support the Agency's permit-issuing and standard-setting processes, and to allow for the development and utilization of energy sources in an environmentally acceptable manner. Research will be conducted to expand our knowledge of the phenomenon of acid deposition; provide information upon which mitigation decisions may be made; and provide data on the performance, reliability, and cost of the Limestone-Injection Multi-Stage Burner (LIMB) control technology.

Acid deposition research is coordinated through the NAPAP, which is administered by the Interagency Task Force on Acid Precipitation. EPA is one of three joint chairs of the Interagency Task Force. The term "acid rain" is used to refer to the atmospheric deposition of acidic or acid-forming compounds in either their dry or wet form. These compounds exist in the atmosphere as gases or aerosol particles containing sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrogen chloride, sulfuric acid, nitric acid, and certain sulfate and nitrate compounds. The objectives of acid deposition research are to develop the necessary data to fully understand the sources and characteristics of acid deposition and to determine the extent of current damage or potential damage. This information is essential to the development of effective corrective strategies if such strategies are deemed necessary.

The other major research area is the development and demonstration of LIMB emission reduction technology. LIMB technology combines low NO_x burners with upper furnace sorbent injection for control of SO_2 emissions. The EPA-industry cofunded wall-fired boiler demonstration testing began in 1987. A tangentially fired boiler demonstration with cofunding from EPA, DOE, and industry was initiated in 1987, and testing will commence in 1989. Successful demonstration of this technology may substantially lower the capital operating cost of retrofit SO_2 and NO_x control.

Major Research Issues

Emissions Inventories of Acid Precursors

How can emissions inventories be made more responsive to acid rain modeling and assessment needs?

Estimates of current emission rates (aggregated at the national level) are reasonably accurate for major categories of man-made acid deposition precursors. However, atmospheric transport models under development will require improvements in spatial and temporal resolution of emissions estimates.

Greater uncertainties exist in projecting future emissions, the effect of possible emissions-control requirements, and their probable costs. The mix of emission sources in any specific region may also change with time. Efforts to project future emissions rates and to estimate the cost of alternative emissions-control strategies are dependent upon the development or improvement of models that replicate the behavior of each important "emitting sector" of the economy. These cost estimates must be consistent with methods that have been fully reviewed by the engineering and economic communities. Future estimates of emissions will rely more on actual data and detailed emissions models.

Atmospheric Processes Affecting Acid Deposition

How can the transport, chemical transformation, deposition processes, and the exposure of ecologically sensitive areas and man-made materials be determined?

The transport, chemical transformation, and deposition processes associated with acid deposition will be investigated on both the regional and meso scales.

Our understanding of the atmospheric transport, physical and chemical transformation, and deposition processes of pollutants emitted into the atmosphere continues to improve. The program continues to emphasize model development, the collection of field data, and model evaluation to better differentiate the contribution of local versus distant sources of acid deposition. Results from this research will enable policy makers to predict changes in deposition levels resulting from reductions in nearby or distant emissions.

The Regional Acid Deposition Model (RADM) is an assembly of model components (modules or submodels) designed to simulate transport, dispersion, chemical transformation, precipitation scavenging, and dry

deposition. These modules will be updated and revised as the uncertainties in the processes become better understood and characterized. Field study data will be generated to improve our scientific confidence in RADM. RADM will be used in a number of important areas (e.g., to calibrate Lagrangian models, to assess engineering applicability and cost control, to perform source-receptor analysis, and to assess materials damage).

Dry-Acid Deposition Monitoring

What is the best method to obtain dry deposition monitoring data comparable to that from the existing National Trends Network (NTN) which concentrates on wet deposition?

The acid rain research program has been compiling several years of nationwide deposition data from wet precipitation. It is well known, however, that humidity and dry sources of acid deposition in the form of dust constitute a potentially significant component of total deposition. Very little data exist on this dry deposition due to the difficulty in developing and deploying accurate monitoring instruments. Also, dry deposition rates vary with surface cover and topography, as well as with environmental variables such as wind speed and humidity. As a result, the actual contribution of dry deposition in most areas is only estimated within an order of magnitude.

Prototype monitors do not measure dry deposition fluxes directly. Instead, they measure ambient air concentrations and use empirical factors to estimate the dry deposition rate. These monitors are being deployed in a network, in many cases co-located with wet deposition collectors. Samples are to be collected and analyzed in a central laboratory. The first several years will be dedicated to installing the network and making it fully operational. Once this is accomplished, the research emphasis will shift to developing direct methods of measuring the dry deposition rate.

Aquatic Effects of Acid Deposition

What future changes in surface water chemistry will occur assuming various levels of acid deposition, and what is the extent and rate of change to aquatic resources stemming from acid deposition?

The Aquatic Effects Research Program was developed to determine the effects of acidic deposition on surface waters of the United States. The program focuses on four policy questions: (1) What is the extent and magnitude of

past change attributable to acidic deposition? (2) What change is expected in the future under various deposition scenarios? (3) What is the target loading below which change would not be expected? (4) What is the rate of recovery if deposition decreases? The goal of the program is to characterize and quantify with known certainty the subpopulation of surface waters which will respond chemically to current and changing acidic deposition and to determine the biological significance of observed or predicted changes. The Aquatic Effects Research Program has five major component programs designed to increase understanding of long-term acidification: the National Surface Water Survey, the Direct/Delayed Response Project, Watershed Processes and Manipulations, Long-Term Monitoring, and Indirect Human Health Effects. Short-term acidification is being addressed through the Episodic Response Project. Biologically Relevant Chemistry addresses issues of both chronic and acute acidification.

National Surface Water Survey: The emphasis of the National Surface Water Survey, now in the final stages of the synoptic survey approach, will shift from collecting high-quality baseline data to refining estimates of the current status and extent of acidic and potentially sensitive aquatic systems. Of primary importance will be an effort to maximize the usefulness of information available from the synoptic survey data base to classify systems. The approach will be to focus on refining the estimates by considering small lakes and streams, aquatic systems outside the National Surface Water Survey study regions, seepage lakes, and alpine lakes. Smaller scale studies addressing a specific question (e.g., mercury in fish, drinking water studies, and shallow aquifer acidification) will continue to focus on policy-relevant issues.

Direct/Delayed Response Project: The Direct/Delayed Response Project will continue to analyze watershed response to acidic deposition in the Northeast and Southern Blue Ridge Province. These analyses are being extended to include the Mid-Appalachians. Future activities will emphasize integrating watershed and surface water data and developing procedures to classify watershed responses as a function of acidic deposition. The classification approach will employ multivariate statistical procedures, empirical models, and dynamic watershed models to correlate future watershed response estimates with the current resource status. These classification procedures and protocols will contribute to

the development of dose-response relationships through predictions of acidification or recovery of surface waters.

Watershed Manipulation and Process Studies: The Watershed Manipulation Project will continue manipulation and process studies at the Maine watershed site. These studies, which will continue beyond 1990, will provide long-term verification of Direct/Delayed Response Project forecasts and identification of processes and watershed interactions controlling surface water acidification, through a number of highly integrated soil process studies, e.g., sulfate mobility, aluminum mobilization, and base cation supply and mineral weathering. Some of the Watershed Manipulation Project studies will be integrated with the Episodic Response Project. Other studies will be implemented to determine if the Direct Delayed Response Project dynamic models and other more simplistic, steady-state models can be used to predict recovery in response to lower levels of acidic deposition relative to current levels. The Little Rock Lake acidification study will continue to examine chemical and biological response to direct additions of acids, providing data for examination of a number of acidification-related hypotheses. Studies are being initiated to evaluate the applicability of the findings to other regions and to examine how similar the response of Little Rock Lake is to other sites in the area which have longer-term data records.

Episodic Response Project: The Episodic Response Project will help to refine estimates of the size of the aquatic resource that has changed or is at risk of changing due to acidic deposition. The Episodic Response Project focuses on acquiring biologically relevant chemical data in order to gain a better understanding of biological effects due to acute acidification, principally, effects on fish. The specific objectives are to understand the frequency, duration, and magnitude of episodes, the key factors that influence their occurrence, the impacts episodes have on fish populations, and their regional extent. A fifth objective is to contribute to the identification of region-specific, dose-response estimates.

Data from intensive experimental studies on hydrochemical and biological processes, along with limited surveys of chemistry and fish (including bioassay data), will form the basis for developing regionally applicable modes of chemical and biological response. After calibration and verification, the models will be applied to the statistical frame of the National Surface Water Survey to provide estimates of biologically relevant chemical data as well as effects on fish on a regional basis.

The Fernow Watershed in West Virginia has been selected for implementing the first intensive experimental studies. This site has been the focus of an ongoing study funded by the USDA-Forest Service and thus provides empirical data needed to begin model development and verification. Field studies are expected to begin late this year at this intensive site. Fish studies and episodes monitoring will begin early next year.

Long-Term Monitoring: By 1990, sites for the Temporally Integrated Monitoring of Ecosystems study will be established throughout the United States. The objective of studying these sites is the timely identification of changes in surface water chemistry related to increased or decreased levels of acidic deposition. The monitored systems will be selected so that evidence of recovery or acidification can be used to infer regional changes through the regionalized frame developed for the Aquatic Effects Research Program. If significant changes or trends are detected, an additional survey of the potentially affected surface waters can be conducted. The data from this survey, when compared to the results of the National Surface Water Survey data, will serve as a warning or a recovery index. Complementing this project are two supporting projects designed to improve presently used analytical methods and to quantify data quality through rigorous quality assurance evaluations. These projects will enhance the capability of detecting trends and will improve the certainty with which long-term, regional-scale conclusions can be made.

Synthesis and Integration: A major emphasis for the program from 1987 and beyond will involve developing the classification scheme described above. These analyses are the foundation for the report on program results that will contribute to the 1990 NAPAP assessment. Because not all components of the program are expected to be completed in time to contribute to the assessment, synthesis and integration will continue beyond 1990. Key issues to be examined beyond 1990 include the influence of episodes on surface water response, providing data on potential nitrate acidification to refine dose-response relationships, and corroborating or modifying acidification and recovery predictions through long-term monitoring.

Terrestrial Effects of Acid Deposition

What is the effect of acidic deposition, alone or in combination with other pollutants, on forests?

Forest effects studies in acidic deposition have been focused in the Forest Response Program, jointly funded and managed by the EPA and Forest Service. This program was initiated in 1983 in response to public concern over the role of acidic deposition and air pollutants in forest decline.

The mission of the program is threefold: (1) to determine if acidic deposition, alone or in combination with other pollutants, is causing or contributing to forest decline in the U.S., (2) if so, to determine the mechanism of effect, and (3) if so, to determine the dose-response relationship of forest response to loadings of acidic deposition, alone or in combination with other pollutants.

To meet the goals of the Forest Response Research Program, research has been organized to include historical data analysis, controlled lab and field experiments, site investigations, and monitoring. Research will be undertaken by Research Cooperatives organized by forest type. In areas where phenomena have been reported, field investigations and historical review activities will concentrate on examining forest condition in relation to atmospheric deposition and natural factors. These Cooperatives will also sponsor controlled lab and field studies to test hypotheses of damage relevant to forest type and deposition scenario. The Eastern Hardwoods Cooperative and the Western Forest Cooperative will initially undertake exploratory research to identify if further research is needed in these forest types.

The Mountain Cloud Chemistry Program is investigating the mechanisms of tree dieback and reduced growth rates at higher elevations in the East. These appear to increase in severity with increasing elevation. To address this research need, monitoring stations are to be established on the slopes and summits of selected mountains and will be co-located with forestry research stations. Samples from the network of forest research and monitoring stations will be analyzed and archived by a central laboratory. Development and standardization of monitoring instruments to perform reliably under the physically demanding conditions at these elevations will be required. A quality assurance and control program will be implemented to ensure long-term usefulness of these data and their intercomparability among sites.

Materials Damage from Acid Deposition

What is the quantitative relationship between acid deposition and damage to structures, buildings, and other materials?

Qualitative relationships between acid deposition and resulting damage have been identified for a few materials under various conditions of exposure. The issue now is to quantify the rate of damage as a function of acid deposition and to extend the development of damage functions to other materials. The assessment of the overall impact of acid deposition on materials also requires knowledge of the distribution of exposed building components and the economic behavior of consumers so that an economic loss may be associated with acid deposition materials.

Damage functions will be derived from physical chemistry theory, chamber studies, and field exposure studies. As we improve our understanding of the basic mechanisms of these damage functions, efforts will shift to predictive models of materials damage that will allow accelerated studies in controlled climate chambers. Studies are under way for galvanized steel and painted surfaces and will be extended to brick, mortar, and concrete.

In addition to the development of physical damage functions, it will be necessary to enhance the materials inventory and make estimates of consumer responses to acid deposition. This includes the way in which the end-of-the-service life of the material is determined, as well as the incremental costs of switching to more durable materials.

Summary of Long-Term Trends

The long-term goals of the acid deposition program are to develop a number of products for policy makers including:

- Inventories and maps showing the magnitude and extent of receptors that have been affected or could be affected by acid deposition;
- Estimates of the rate of change in the extent of effects;
- "Target loadings" of acid deposition for different receptors in different regions of the country;
- Quantification of the contribution of local versus long-range sources to acid deposition; and

- Source-receptor models that can indicate which long-range sources or source regions contribute to acid deposition.

One of the major obstacles that has delayed the scientific understanding of the acid deposition phenomenon and the formulation of control or mitigation options for acid deposition is the lack of high quality data from long-term monitoring programs and from continuously monitored intensive research sites. Several years ago, the acid rain program established a monitoring network for wet deposition (the National Trends Network). This network is just beginning to provide the multi-year data necessary for trends analysis. Efforts are also underway to increase the number of species monitored through the dry deposition network, monitoring of lakes and streams, mountaintop cloud and forest exposure monitoring, and watershed monitoring.

Resource Options

1988 Current Estimate: $ 55.6M
1989 President's Budget: $ 55.5M

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	55.5	55.5	55.5	55.5
Moderate	57.2	58.9	60.7	62.5
High	58.9	60.7	62.5	64.4

No Growth: The program would proceed as described in this Agenda.

Moderate: Additional efforts would be made to evaluate the Regional Acid Deposition Model through field study data.

High: Additional efforts would be made to understand the linkages between terrestrial and aquatic ecosystems as they relate to acid deposition impacts. The program would accelerate acid deposition research to identify cause/effects mechanisms of forest changes and expand the number of representative watersheds under study.

Interdisciplinary

The interdisciplinary research program develops risk assessment guidelines and ensures consistent application of these guidelines throughout the Agency. Activities in this area also support the dissemination of scientific and technical data from ORD. Finally, the interdisciplinary research program provides resources to conduct long-range exploratory research through the grants, centers, and visiting scientists programs and provide central management, audits and compliance monitoring for the Agency-wide Quality Assurance program.

Major Research Issues

Assuring Integrated Risk Assessments

What activities and methods are needed to ensure scientific consistency and technical quality in Agency risk assessments?

This function has four major components: development of risk assessment guidelines, activities of the Risk Assessment Forum, research to reduce uncertainties in risk assessment, and managing the Integrated Risk Information System (IRIS).

The first risk assessment guidelines were issued in 1986. These included guidelines for carcinogenicity risk assessment, mutagenicity risk assessment, health risk assessment of suspect developmental toxicants, health risk assessment of chemical mixtures and estimating exposures. In 1988, the Agency expects to propose guidelines for assessing risk to the male and female reproductive systems and guidelines for systemic toxicants; final guidelines should be issued about a year later. The Agency is also developing guidelines for making and using exposure measurements and for the assessment of ecological risk. The Agency recognizes that guidelines are living documents and are therefore subject to revisions and expansions, which will take place as they are appropriate.

The Risk Assessment Forum was established in 1984. As stated in its charter, it promotes consensus on risk assessment issues and ensures that this consensus is incorporated into appropriate risk assessment guidance. To fulfill this purpose, the Forum formally assembles Agency risk assessment experts to study and report on these issues from an Agency-wide scientific perspective. Forum activities may include: developing scientific analyses, risk assessment guidance, and risk assessment

methodology for use in ongoing and prospective Agency actions; using scientific and technical analysis to propose risk assessment positions; and fostering consensus on these issues. Generally, the Forum focuses on generic issues fundamental to the risk assessment process, on the analysis of data used in risk assessment, and on developing consensus on approaches to risk assessment.

The program of research to reduce uncertainties in risk assessment is a carefully planned effort to develop and/or improve the approaches, methods and knowledge of the basic biological principles underlying risk assessment. Examples of relevant research areas include: development of biologically-based models to extrapolate laboratory-derived data to human risk applications, assessment of risk as a function of differing exposure scenarios and the quantification of exposure that incorporates pharmaco-kinetic/pharmacodynamic factors, and the development of methods that can be directly applied to human populations to assess the occurrence and degree of exposure and estimate the probable health risk.

IRIS is a computer-based file of EPA risk assessment and risk management information for chemical substances. It is designed especially for federal, state, and local environmental health agencies as a source of the latest information about EPA health assessments and regulatory status for specific chemicals. It is intended for users without extensive training in toxicology but with some knowledge of health sciences. IRIS will be made available nationally in FY 1988 and will be continually updated.

Technical Information and Liaison

What activities facilitate technology transfer to regions, states, and affected local governments?

ORD, as the primary research arm of EPA, provides scientific information needed by the regulatory offices of EPA to develop and enforce regulations. Appropriate and timely dissemination of research results supports the scientific basis for EPA regulations and increases confidence in the decision-making process.

The Center for Environmental Research Information (CERI) provides centralized support for the production of information products in a cost-effective manner; ensures consistent, uniform dissemination of research results; and provides a technology transfer program to synthesize information and develop presentations to more effectively

support specific high-priority program objectives at the lowest cost to the government.

CERI will continue to provide support to ORD laboratories by writing summaries of research projects conducted by or for ORD, editing documents and summaries, assuring the quality of material submitted for printing, typesetting and producing documents, assuring the quality of and preparing documents for submission to the National Technical Information Service, controlling the distribution of documents, and responding to requests for publications and documents.

The technology transfer program will assess the status of research and regulations, discuss with the Research Committees their priorities for the dissemination of material, develop innovative information transfer mechanisms, and ensure that information on improved technology and management practices is distributed to appropriate audiences to comply with EPA regulations. All information on products is developed using a team of participants from ORD, EPA program offices, and private industry.

Planned activities include:

- Development of methods manuals for comparing different solid and hazardous waste treatment techniques and implementing those that are appropriate;
- Dissemination of the results of research on the control of hazardous air pollutants;
- Description of technologies, costs, and operating effectiveness of the methods available to meet drinking water regulations for small drinking water systems; and
- Dissemination of information on the effectiveness, cost, and design of new municipal waste treatment technology.

Exploratory Research Program

How will the Agency conduct longer-range mission-oriented research that is not tied to specific regulatory timetables or program office requirements?

Such research will be conducted through the Office of Exploratory Research. The goals of the Exploratory Research program are

1. To make the environmental research community aware of and active in working on problems of interest to the EPA;
2. To promote close interaction and mutual awareness between EPA researchers and the environmental research community; and
3. To provide general support to the research community for work on fundamental environmental research, thereby promoting a solid foundation of knowledge and a cadre of scientific and technical personnel in the environmental sciences.

These goals are achieved through three major programs: (1) a Research Grants Program that provides grant support to investigator-initiated research in the environmental sciences and engineering, (2) an Environmental Research Centers Program that provides funding via cooperative agreements to universities to conduct interdisciplinary research under specific research themes established by the EPA, and (3) a Visiting Scientists Program that attracts outside scientists and engineers to EPA laboratories to conduct research in collaboration with EPA researchers.

To date, the Research Grants Program has supported approximately 600 research projects in priority areas as identified by the Agency's planning mechanisms. The Environmental Research Centers Program currently supports research conducted at eight university-based research centers on various topics of priority interest to the Agency. The Visiting Scientists Program has attracted 20 scientists/engineers to EPA facilities for up to 3-year terms to collaborate on research projects.

Research Grants Program: A primary function of the Research Grants Program is to stimulate extramural scientists to work on EPA's technical problems and to provide a stronger creative base of mission-oriented research needed for the Agency's regulatory and enforcement efforts.

The Research Grants Program solicits investigator-initiated proposals by issuing annually a solicitation document that describes EPA's high-priority, long-term research needs. The solicitation is broadly distributed and is intended to stimulate scientists in the academic, research, and industrial communities to respond with fully developed proposals for innovative research in areas of interest to EPA. Although all valid proposals are considered, the solicitation has typically emphasized research needs in five interdisciplinary program areas: environmental health, environmental biology, environmental engineering, chemistry and physics in air, and chemistry and physics in soils and water. In the future, the emphasis may change to include ORD's major research initiatives.

When the Agency wishes to expand an existing research area or explore a new one in which current Agency efforts are either minimal or nonexistent, targeted grants are awarded in a narrowly defined research topic. The purpose of these exploratory grants is to augment existing research within EPA with more fundamental studies or to determine whether a more substantial research effort should be established by the Agency in the area targeted for study. The Office of Exploratory Research addresses this specific research need by issuing a special solicitation called a request for applications (RFA). The RFA is a mechanism by which a formal announcement is released describing a high-priority initiative in a well-defined scientific area.

The grants selection process uses a dual review system of evaluating research proposals. Ad hoc panels, chaired by scientists or engineers from outside EPA, meet at least twice annually to discuss reviews of each proposal conducted by at least three experts in the relevant field. Applications that pass the scientific panel review are then reviewed by Agency personnel for their relevancy to the Agency's mission. The combined recommendations are rank-ordered and the grants are awarded based upon the availability of funds.

Grant support is typically awarded for two to three years, and an EPA staff member is assigned as a project officer. Project monitoring is accomplished by the submission of technical progress reports and/or the publication of scientific papers in peer-reviewed journals. Staff and formal site visits are conducted when appropriate.

The five interdisciplinary areas of the Research Grants Program are described below.

Environmental Health Research: The major objective of the Environmental Health Research Program is to obtain and provide a scientific basis upon which the Agency can make regulatory decisions concerning the protection of human health from environmental pollutants. The principal concern is to determine whether, and to what extent, exposure to various pollutants contributes to environmentally related health problems. Particular attention in the annual solicitation is given to epidemiological studies, animal toxicology, bioassay development, and mechanisms of action. Major areas of new emphasis will deal with understanding the mechanisms of inducement of disease and pathology, improving the validity of assays as predictors of potential human risks, and developing better model systems to determine the long-term effects of multimedia pollutant exposure.

Environmental Biology Research: The Environmental Biology Research Program supports a broad range of projects in the areas of ecosystem effects, aquatic ecosystem modeling, biotechnology monitoring, environmental assessment, marine studies, and biodegradation in water and soil environments. The aim of the program is to provide a base of scientific knowledge which can be used to identify new and emerging problems and to develop appropriate remedies for their solution. One objective of this program is to provide information that, in combination with exposure data, allows the prediction of the environmental risk of pollution for individual organisms and ecosystems. The risks include the reduction of productivity in agricultural areas, wetlands, and freshwater and coastal marine ecosystems as well as human exposure to toxic substances through accumulation in the food chain.

During the next five years, emphasis will focus on wetland problems and the development of modeling methods for predicting the ecosystem effects on wetlands. Another area of focus will be the development of methods for monitoring genetically modified organisms in the natural environment.

Environmental Chemistry and Physics/Water: The Environmental Chemistry and Physics of Water Program supports research leading to basic scientific tools for establishing the levels at which pollutants occur or might occur in the environment under different conditions.

The program includes projects in analytical chemistry and studies on chemical reactions and their rates and on the physics of the movement of pollutants in the water and soil. The resulting tools and information allow the estimation of exposure levels needed for risk assessment.

The research also provides possible approaches to the treatment of waste sources. It includes small-scale laboratory studies and large-scale field projects relating to the transport and transformation of pollutants.

This program will emphasize problems related to ground water, sediments, and measurement methods. For ground water the emphasis will be on developing the techniques for estimating the parameters used in transport models and in validating the models. In the case of sediments, the focus will be on the physics of movement and the capability of sediments to transport pollutants, particularly heavy metals. Research on measurement methods will continue with some emphasis on methods applicable to sediments and associated substances such as humic materials.

Environmental Chemistry and Physics/Air: The Environmental Chemistry and Physics of Air Program is concerned with the study of the sources, transport, transformation, and fate of air pollutants. The program reviews applications dealing with studies on time-space patterns of pollutant concentrations, detailed chemical and physical descriptions of pollutants, mathematical models connecting air pollutants with probable sources, and procedures for investigating the impact of pollutants on human health. The program draws upon the concepts and procedures of physics, chemistry, and meteorology using models and measurement methods to develop quantitative descriptions of these phenomena.

This program will emphasize models or other means of connecting air pollutants at a location with the contributing sources, the atmospheric chemistry of polyaromatic hydrocarbons (important toxic compounds), and reliable measurement techniques for detecting the particulates of significance to health.

Environmental Engineering Research: The Environmental Engineering Research Program supports more basic fundamental research needed to provide solutions to multimedia pollution control problems outside the scope of the Agency's response-directed research program. Therefore new, innovative pollution control and waste management techniques are sought to provide cost-effective solutions to complex problems involving air, water, and soils. Areas emphasized include water disinfection, wastewater treatment, water-related process biomonitoring methods, residuals control, and air pollution concerning VOCs, fine particles, SO_x, and NO_x. Hazardous wastes continue to receive particular attention.

especially incineration processes and improved cleanup techniques.

Environmental Research Centers Program: As part of EPA's strategy for approaching long-term research needs, ORD has created the Environmental Research Centers Program to support environmental research in science and engineering. The objective of the program is to support high-quality exploratory research in areas of importance to EPA. It is achieved by providing stable funding to institutions with a demonstrated capability and interest in a major area of research of concern to EPA. The program, which was established in 1980, consists of eight university-based environmental research centers working in four general areas: (1) industrial and municipal waste abatement and control, (2) pollutant transport and transformation, (3) ecological and biological effects of pollutants, and (4) environmental epidemiology. Each broad area of research is discussed below.

Industrial and Municipal Waste Abatement and Control: Three centers conduct research in this area. The Industrial Waste Elimination Research Center (IWERC) focuses its attention on reducing or eliminating the creation of pollutants. Two centers, the Advanced Environmental Control Technology Research Center (AECTRC) and the Hazardous Waste Research Center (HWRC), study the removal of wastes once they are formed. The AECTRC works primarily on the removal of contaminants from dilute waste streams, such as sewage discharges and stack effluents, while the HWRC studies methods to stabilize, detoxify or destroy waste products containing high concentrations of hazardous pollutants.

The principal areas of research at IWERC, listed in order of current priority, are: (1) metals speciation and separation, (2) sorption/desorption phenomena, (3) particle size and shape control, and (4) process catalysis and control. This priority list is not expected to change significantly, though more emphasis will be placed in the future on process and catalysis control, and on particle size and shape control.

AECTRC has investigated the degradation of low concentrations of organic contaminants in drinking water sources using biofilm systems. This work is expected to expand in the future, as is work on the supercritical extraction of pollutants. Current work on wet air regeneration of powdered activated carbon will be deemphasized. In the area of air pollution, AECTRC will increase efforts on studying the simultaneous collection of submicron aerosol particles, sulfur dioxide, and oxides of

nitrogen. With respect to the indoor radon activities, a systematic study will be made of the adsorption of radon on charcoal as a function of charcoal type, design parameters of the collection system, and interference from other gaseous species.

The HWRC will continue to emphasize the destruction, separation, and stabilization of hazardous waste constituents, particularly the development of optimal design parameters for complete or nearly complete incineration of combustible organic hazardous wastes. Future research will focus on: (1) the operation and modeling of a full-scale industrial incinerator, (2) in-situ biodegradation of targeted environmental toxins in soil, (3) investigations of the feasibility of rotary kilns as low energy thermal desorbers for soil and solid waste contaminated with organics, and (4) the transport mechanisms involving pure organic phases in the unsaturated and saturated zones below spill and dump sites.

Pollutant Transport: Two centers study the movement and alteration of pollutants in the environment.

The National Center for Ground Water Research (NCGWR) devotes itself to understanding the movement and alteration of pollutants through the subsurface environment. Directly or indirectly, ground water is the major source of the nation's drinking water, but it may be contaminated with pollutants from a wide variety of sources. Efforts to mitigate this contamination are complicated by the extremely slow movement of pollutants underground.

In the next five years, the NCGWR will emphasize studies on subsurface biodegradation and on facilitated transport of trace organic compounds in saturated aquifers. Future studies will deal with microbial metabolism as a process involved in the fate of contaminants. The comparative ecology of aerobic microbes as influenced by subsurface parameters such as soil type and electron acceptors will be studied in order to predict and control microbial involvement in the fate of contaminants at hazardous waste disposal sites. Current work on subsurface anaerobic environments will be expanded to include isolation of chemical intermediates and end products. Another new project will be initiated, using state-of-the-art optical techniques, to determine whether sorption of contaminants is dominated by organic carbon or mineral surfaces.

The other center, the National Center for Intermedia Transport Research (NCITR), studies the important physical and chemical processes associated with the transport of particulate or gaseous environmental pollutants from one medium to another. Current and future studies at NCITR will emphasize the movement of hazardous wastes through air, land, or water.

Specific projects at the NCITR will concentrate on five topics: wet and dry deposition, soil and water processes, multimedia transport, ecosystem modeling and structural characterization, and source allocation. Plans for research include development of an improved correlation between dry deposition velocity and the roughness layer; determination of the ambient compositions and concentrations of organic pollutants in rain, fog and dew; studies on the chemisorption of halocarbons by clay; and the mitigation of organic pollutants in the unsaturated soil zone. In addition, NCITR will maintain current levels of research on studies to determine the significance of nitrogen-bearing trace compounds in air to nitrogen levels in desert ecosystems, the transfer rate of submicron aerosols to vegetation, and the effects of vegetation on the transfer of atmospheric pollutants.

Ecological and Biological Effects: Research on ecological and biological effects is conducted at two centers: the Ecosystems Research Center (ERC) and the Marine Sciences Research Center (MSRC). The mission of the ERC is to evaluate the state of knowledge on whole biological communities and ecosystems and to investigate its applicability to environmental regulation and management. Research conducted at ERC is in the areas of ecotoxicity, biotechnology, air pollution effects on forests, plant-pest interactions, and impact assessment for the Hudson River system. ERC has also developed projects in two additional areas. The first of these, functional classification of ecosystems, has as its eventual goal the classification of ecosystems into functional types, both in terms of the natural rates at which processes occur and in terms of their responses to anthropogenic disturbances. The other area of research is freshwater wetland ecosystems. The purpose of this project is to develop concepts and methods for simplifying assessment of the effects of human-induced changes in hydrology on northern freshwater wetlands.

The objective of research at the MSRC is to increase understanding of processes in coastal marine ecosystems that are of importance in evaluating the effects of pollutant discharges. The primary approach to research at MSRC

is experimental, specifically, the use of mesocosms as models for predicting the responses of biological communities in coastal systems to pollutant loadings, and to determine the fates of pollutants. Such mesocosms fill a gap between laboratory experiments and field observations.

A major shift in research emphasis at MSRC is occurring. Previous studies emphasized the determination of the fates and biological effects of sewage sludge, fuel oil, and specific hydrocarbons. These studies were "passive" in the sense that they described impacts of pollutants on coastal systems. In the future, more emphasis will be placed on studies whose objective is to recommend methods for control of unsightly, odorous coastal waters, rather than simply predict the occurrences of such events. MSRC has developed a program to determine the efficacy of silica enhancement of ocean outfalls to control the explosive growths of phytoplankton (e.g., red tide) often associated with mephitic waters. Another major effort is a field program to evaluate the state of Narragansett Bay with respect to a number of environmental features related to pollution or other anthropogenic effects. This effort is being carried out in cooperation with other studies of pollutant inputs, shellfish health, bacterial contamination, hydrodynamic modeling, etc., in association with the Narragansett Bay Project, also supported by EPA.

Environmental Epidemiology: The area of environmental epidemiology is addressed by one center, the Center for Environmental Epidemiology. Its primary objective is to improve the theoretical understanding of the human health risks associated with environmental pollution. The center has established four research priorities: (1) problem definition and feasibility assessments for epidemiology studies; (2) research to develop and improve epidemiological methods related to environmental health, for example, research on statistical and analytical methods; (3) research on exposure assessment relevant to epidemiological investigations; and (4) research support to EPA including review of data and reports, and identification of problems where epidemiology can support EPA's mission.

Emphasis is given to indoor air contamination, where research will focus on inhalation exposures to volatile constituents from water used for purposes other than drinking. A project relating to volatile constituents from shower water will be completed and a new study initiated to determine the source, strengths, and dissemination of indoor volatile and gaseous constituents from water and other materials. Plans will be made to extend this project

to measurements of organics in exhaled air of humans in homes where environmental exposures have been well characterized. This research will be a joint project between the University of Pittsburgh and Carnegie-Mellon University.

Efforts will be directed toward better characterization of environmental contamination. Work will be carried out on the development of a passive sampler which has optimal properties for the routine monitoring of airborne vapors at very low concentrations such as are found in the general environment.

Some preliminary investigations will also be made in an area new to the center. This area is characterized by heterotrophic bacteria in air and water and the identification of pathogens. Work here will be exploratory and will be closely coordinated with work being conducted elsewhere in EPA. There is some evidence that these bacteria are important in human respiratory disease.

Visiting Scientists Program: The Office of Exploratory Research (OER) has administered a Visiting Scientists Program since 1984. The general purpose of the program is to provide a cross-fertilization between the EPA and the scientific community by attracting outside environmental scientists and engineers to the Agency on a temporary basis to collaborate in environmental research. The program has two components: a Visiting Scientists and Engineers Program and an Environmental Science and Engineering Fellows Program.

Visiting Scientists and Engineers Program: The Visiting Scientists and Engineers Program attracts eminent scientists and engineers to the Agency's research laboratories for up to three years to collaborate in environmental research efforts beneficial to both the Agency and the visitor. Selections are made annually through a competitive process. Since its inception in 1984, the program has attracted 20 such visitors to the Agency to explore a range of environmental issues and problems. At present, 15 visitors are involved in research at the following 7 ORD laboratories: Environmental Research Laboratory, Gulf Breeze, Florida; Environmental Research Laboratory, Corvallis, Oregon; Health Effects Research Laboratory, Research Triangle Park, North Carolina; Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio; Environmental Research Laboratory, Athens, Georgia; Environmental Monitoring Systems Laboratory, Las Vegas, Nevada; and Water Engineering Research Laboratory, Cincinnati, Ohio.

Environmental Science and Engineering Fellows Program: In cooperation with the American Association for the Advancement of Science, OER supports 10-week summer appointments of postdoctoral and midcareer environmental scientists and engineers to EPA facilities to conduct interdisciplinary mini-assessments of environmental problems and options. This program was initiated in 1980 as part of ORD's outreach activities directed toward identifying and evaluating long-term environmental issues. To date, 54 fellows have participated in the program.

Quality Assurance

How does the Agency assure that its environmental data collection is of high quality?

A significant portion of EPA's budget is spent on collecting environmental data. Quality assurance activities play an integral role in the planning and implementation of environmental data collection efforts and in the evaluation of the resulting data. Quality assurance (QA) is the process of assessing whether the data provided by data collectors to line managers is of the quality needed and claimed. Quality assurance should not be confused with quality control (QC); QC includes those activities required during data collection to produce the data quality desired and to document the quality of the collected data (e.g., sample spikes and blanks).

The Quality Assurance Management Staff (QAMS) is charged with overseeing the quality assurance activities of the Agency. QAMS came into being in May 1979, when the Agency recognized the need for formalizing an Agency-wide quality assurance program for all environmental data collection activities. More recently, with the issuance of EPA Order 5360.1 in April 1984, the Agency's quality assurance program has been significantly strengthened and broadened. The Order mandates that QA be an integral part of all environmental data collection activities, from planning through implementation and review.

In recent years, the Agency's QA activities have focused on identifying the basic elements that are essential to effective quality assurance for environmental data. QAMS has put considerable effort into issuing guidance defining and analyzing these key elements. The long-range outlook for the QA program is a transition from the guidance phase to implementation. During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following

priorities: (1) quality assurance program plans; (2) data quality objectives; (3) management systems reviews and audits of data quality; and (4) documentation of routinely used measurement methods.

Summary of Long-Term Trends

The basic goal of the scientific assessment activity will continue to be ensuring Agency-wide consistency and high technical quality in risk assessments. This will be especially critical as the Agency moves increasingly toward risk-based decision making and toward decentralization of risk assessment. Development or revision of risk assessment guidelines will continue. The Risk Assessment Forum will continue to consider health risk issues but will emphasize exposure assessment issues to the extent that resources are available. The current OHEA research program to reduce uncertainties in risk assessment will continue and will be carefully integrated with other risk assessment research programs. New chemicals will be added to IRIS, existing information will be updated, and new files will be created as needed.

Technology transfer is a continuing responsibility. In response to requests from the EPA program offices and the needs expressed by the regions and the states, ORD disseminates the available technology and technical data to states and localities to enable them to meet their regulatory responsibilities. Technology transfer activities will include the design, production, quality control, and distribution of materials such as design manuals, user's guides, handbooks, and workshops.

The goals of the research grants and centers program are to stimulate investigation of emerging environmental problems and identify steps that can predict their occurrence, address exploratory research needs of importance to EPA's mission that require multimedia and multidisciplinary approaches, extend the capabilities of EPA's laboratories, and establish links between EPA and the scientific and technical communities.

Among the areas that will be emphasized in the grants program during the next five years are modeling of wetlands ecosystem effects, the capability of sediments to transport heavy metals, and incineration processes for hazardous wastes. In the centers program, the trend will be to increase research on hazardous waste removal and control, modeling of marine ecosystems, and control of indoor radon.

During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following priorities: (1) QA program plans; (2) data quality objectives; (3) management systems audits and audits of data quality; (4) documentation of routinely used measurement methods; and (5) QA outreach and training.

Resource Options

1988 Current Estimate: $ 26.9M
1989 President's Budget: $ 34.1M

	Projections			
Growth	FY 1990	FY 1991	FY 1992	FY 1993
None	34.1	34.1	34.1	34.1
Moderate	35.1	36.2	37.3	38.4
High	36.2	37.3	38.4	39.6

No Growth: The program would proceed as described in this Research Agenda.

Moderate: Additional monies will be prorated across the activities of the Interdisciplinary Research Committee with the following activities receiving support:

1. Expansion of Risk Assessment Forum activities, with emphasis on exposure issues as well as health issues;
2. Solid hazardous waste technology transfer expansion;
3. Acceleration of development of the processes for implementing audits of data quality; and
4. Increase in the number of new grants funded.

High: Additional monies will be prorated for:

1. Initiating a major, ORD-wide research program to reduce uncertainties in risk assessment;
2. Developing ecological risk assessment guidelines, in addition to ongoing work on health risk assessment guidelines;
3. Providing to state and regional personnel seminars and manuals on protection of drinking water supplies from surface leaching and ground-water contamination;
4. Further strengthening of QA oversight; and
5. Increasing support for the Research Centers towards SAB recommendation.

III. APPENDIX

Interagency Coordination

Reorganization Plan 3, which established the EPA, did not intend that all relevant environmental research be included within the EPA in-house research establishment. The Agency was expected to rely in part on relevant research and development performed by other federal agencies as well as non-federal organizations.[1] Acquiring and integrating such information was considered to be an important function of the EPA R&D operation.

A review of the recent Directory of Federal Laboratory and Technology Resources[1] indicates the breadth of environmentally related research and development being done in the non-EPA federal laboratories. In order to prevent unnecessary duplication of research efforts, awareness of such activities and available information is considered in the development of the EPA research program.

In addition, interagency cooperation and coordination is utilized to bring the appropriate expertise to bear on environmental problems. Interagency committees and interagency agreements are techniques utilized to effect the communication and coordination.

The Office of Research and Development presently has active interagency agreements with the following agencies:*

- Department of Agriculture (measurements, ecology, transport and fate, health, engineering)
- Department of Defense (measurements, engineering)
  - Army (measurements, ecology, health, engineering)
  - Army Corps of Engineers (engineering, measurements, ecology)
  - Navy (engineering, measurements, transport and fate)
  - Air Force (engineering, measurements, ecology, transport and fate, health)

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[1] Directory of Federal Laboratory and Technology Resources, 1986-1987, PB86 100013, Center for Utilization of Federal Technology, U.S. Department of Commerce, NTIS, 1986.

* Disciplines and/or areas of cooperative agreement are inserted parenthetically.

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- Department of Commerce (measurements, ecology, health, engineering)
  - National Bureau of Standards (measurements)
  - NOAA (transport and fate, ecology)
- Department of Energy (engineering, assessment, measurements, ecology)
- Executive Office of the President (measurements, exploratory research)
- Department of Health and Human Services (ecology, health, engineering)
- National Aeronautics and Space Administration (health, ecology)
- Department of the Interior (measurement, ecology)
- Geological Survey (training, technical assistance, transport and fate, monitoring)
- Fish and Wildlife Service (ecology)
- National Science Foundation (exploratory)
- Tennessee Valley Authority (ecology, measurement)
- Department of Transportation (engineering)

Examples of the interagency committees on which EPA/ORD is represented include the following:

- Interagency Committee for Stratospheric Ozone Protection
- Task Force on Environmental Cancer and Health and Lung Disease
- Interagency Committee on Indoor Air Quality
- Committee on Ocean Pollution Research, Development, and Monitoring
- National Acid Deposition Assessment Program
- Biotechnology Science Coordinating Committee
- Interagency Advisory Committee on Water Data

Science Advisory Board Letter

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

February 10, 1988

SAB-EC-88-022

OFFICE OF
THE ADMINISTRATOR

Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Thomas:

The Science Advisory Board has conducted a series of scientific reviews of Agency research programs that have proven to be a highly useful means of assessing the quality and relevance of existing research, identifying research needs and involving the scientific community in the research planning process. Such reviews have also aided internal communication within the Office of Research and Development (ORD) and between ORD and the program offices.

In FY 87 the Science Advisory Board reviewed research programs on land disposal, waste minimization, the mitigation of radon in houses, drinking water disinfectants and their by-products, municipal waste combustion, and extrapolation modeling. The Clean Air Scientific Advisory Committee identified needed research for planned revisions of the National Ambient Air Quality Standards for lead and ozone. Board members also reviewed over 100 papers published by EPA scientists to identify those of sufficient quality and importance to qualify for EPA's Scientific and Technological Achievement Award. In September 1987 the Science Advisory Board initiated development of a research strategy for the Environmental Protection Agency. The strategy will address health effects; ecological effects; exposure; sources, transport and fate; and risk reduction.

The purpose of presenting this information is to inform you that such activities have focused both the SAB's and the Agency's thinking on research plans and needs to a degree never before achieved through preparation and review of the Five Year Research and Development Plan (Research Outlook). As you know, Congress has required that the Agency provide the SAB with the opportunity to review the plan. The Board believes that its extensive research program reviews fulfill the spirit and intent of Congress for SAB oversight of the Agency's program. Comments on specific issues in the five year plan have also been addressed in individual research program reviews.

The Board reiterates its long-standing support of research addressing problems beyond the immediate regulatory needs of the Agency.

Sincerely,

Norton Nelson

Norton Nelson, Chairman
Executive Committee
Science Advisory Board

*U.S. GOVERNMENT PRINTING OFFICE 1988-548-158/67135